From:	Weiss, Steven (MPCA)
To:	Pierard, Kevin
Cc:	Ramach, Sean; Holst, Linda; Kessler, Katrina (MPCA); Wasley, Dennis (MPCA); Luckstein, Aaron (MPCA); Turri, Wendy (MPCA)
Subject:	Minnesota RES Implementation Guidance - an old draft
Date:	Thursday, September 25, 2014 1:28:50 PM
Attachments:	image001.png Implementation of River Nutrient Eutrophication Standards revisions October 2012.docx

Kevin,

In response to your resent request, please see the attached draft implementation guidance for river eutrophication standards. As you can see, this document was developed in 2012 as a companion to our SONAR. Keep in mind that we are currently working with Sean to develop a finalized document that will likely include more detailed effluent calculation steps. Feel free to call if you have questions.

Steve

Steven Weiss
Supervisor | Effluent Limits Unit
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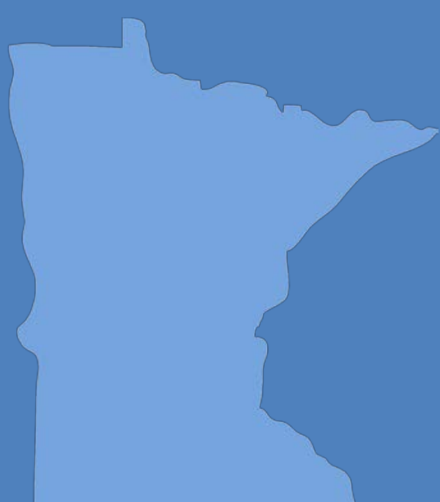
Minnesota Pollution Control Agency

Minnesota Pollution Control Agency

Implementation of River Eutrophication Standards: effluent limit setting procedures for NPDES permitted wastewater facilities

For use after adoption of river eutrophication standards
DRAFT November 2012



Minnesota Pollution Control Agency

November 2012

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Document number:

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Executive Summary

The reader may wonder why this document is necessary given that procedures for setting effluent limits for wastewater treatment facility point sources [WWTF PS(s)] to protect designated uses in receiving waters are already available in federal documents. The available procedures were designed to protect receiving waters from toxic pollutants during low flow conditions. River eutrophication standards apply to all summer (June-September) days and also include response variables which generally characterize algal levels in the river. Thus, procedures for establishing effluent limits for river eutrophication standards must examine a range of flow conditions and identify where/if the phosphorus of the discharge manifests as a response variable downstream of the discharge point. Phosphorus is generally conservative in rivers so multiple WWTF PSs will likely be evaluated while establishing effluent limits for a given WWTF PS. Finally, non-point sources of phosphorus are considerable in some areas of Minnesota due to phosphorus attached to suspended solids. Existing federal procedures for establishing effluent limits do not consider that upstream sources of a pollutant are controllable. MPCA has developed numerous turbidity TMDLs to address excess turbidity in rivers, and implementation of these TMDLs will reduce non-point loads of phosphorus. Clearly, eutrophication standards are unique water-quality standards as discussed above. MPCA has developed effluent limit setting procedures specifically for river eutrophication standards to address deficiencies and inconsistencies with existing federal procedures for establishing effluent limits for WWTF PSs.

MPCA promulgated lake eutrophication standards in 2008. This is important since approximately 80% of the state's NPDES wastewater discharges are located upstream of lakes with excess nutrients. Most WWTF PSs in Minnesota are to rivers and streams, but there are a few key lakes and reservoirs in the state located on large river networks. Lake Pepin is an example of a natural riverine lake with a large watershed containing many WWTF PSs. Since 2010, MPCA has developed total phosphorus water-quality based effluent limits for WWTF PSs upstream of lakes impaired for excess nutrients. The procedures for establishing these limits are basically the same as the procedures outlined in this document. River eutrophication standards will require staff to assess the response of algae to phosphorus inputs from WWTF PSs for downstream streams, rivers, reservoirs and lakes. Effluent limits will be based on meeting designated at downstream surface waters where cause (i.e total phosphorus) and response variables (chl-a, BOD, DO flux, pH) exceed applicable eutrophication standards. There may be some instances where response variables are not exceeded in immediate receiving waters, but our analysis indicates that there is likely a downstream surface water where algal levels do exceed river and/or lake standards.

Three watersheds were examined to illustrate the process of setting effluent limits once river nutrient standards are adopted. It is important to note that example watersheds are based on the information available at the writing of this document and effluent limits suggested in this document do not represent final effluent limits. The Cottonwood River Watershed in southern Minnesota represents a watershed that exceeds the proposed river standards primarily due to non-point loading of total phosphorus with modest loads from point sources. Current effluent limits in this watershed may be sufficient given their relatively minor contribution of

WWTF PSs to the overall phosphorus loading in the watershed. The South Fork Crow River Watershed exceeds the proposed river standards due to a combination of loads from point and non-point sources. Significant reductions in both point and non-point sources will needed to river nutrient standards. Existing effluent limits for some WWTF PSs in this watershed are likely insufficient to meet the proposed rivers standards. In the final example, the Big Fork River Watershed in northern Minnesota represents a resource that meets the proposed river nutrient standards. Existing effluent limits for WWTF PSs in this watershed are likely sufficient to protect the Big Fork River at the outlet of this watershed.

In summary, this document was written to explain the process of establishing water quality based effluent limits for WWTF PSs to be consistent with both river and lake eutrophication standards. The document allows some flexibility in the process of calculating effluent limits given the diversity of both NPDES discharges and watersheds in Minnesota. Total phosphorus loads from NPDES wastewater discharges have been reduced dramatically in the past decade due to the MPCA phosphors strategy, TMDLs, voluntary efforts of NPDES discharges and a 1 mg/L technology based limit in Minnesota state rule. The implications of these reductions are still being documented by the extensive river monitoring network in Minnesota. Effluent limit setters will ultimately determine if existing limits technology and/or TMDL limits for total phosphorus are sufficient to meet water-quality based limits to protect the designated uses of downstream lakes and rivers. Special consideration will be given to the contribution of WWTF PSs during low to moderate flows in summer when conditions are favorable for algal response.

Introduction

Most wastewater treatment facility point sources [WWTF PS(s)] in Minnesota discharge to streams or rivers (hereafter rivers). Implementation of river eutrophication standards (RES) requires consideration of applicable effluent limits for these point sources prior to issuance of National Pollutant Discharge Elimination System (NPDES) permits. **The primary purpose of this document is to provide guidance for MPCA staff implementing RES as WWTF PS total phosphorus (TP) limits in NPDES permits.** Historically, TP effluent limits were triggered by a WWTF PS expansion and were generally designed to reduce nutrients to receiving waters without a specific instream target for the immediate watershed (MPCA Phosphorus Strategy, March 2000). Many of these limits were/are technology based and still exist in current permits. Since 2010, water quality based effluent limits (WQBELs) have been included in permits to protect downstream lakes or reservoirs such as Lake St. Croix, Lake Byllesby, and Lake Pepin. With the promulgation of RES, MPCA will be able to determine if a given WWTF PS at current discharge limits has the reasonable potential to cause or contribute to an exceedance of RES in downstream rivers and therefore, needs a WQBEL. Existing limits are likely to be sufficient in rivers where RES are currently met instream. The reasonable potential process and WQBEL implementation procedures outlined in this document will be completed using information available prior to permit issuance. In general, WQBELs for a given WWTF PS to comply with RES will often be less restrictive than the TP concentration listed in RES for a given river eutrophication region (RER).

Implementation of lake and reservoir eutrophication standards have resulted in WQBELs for point sources that discharge upstream of lakes and reservoirs (hereafter lakes). The process of setting effluent limits for RES is similar to the process that the agency uses to set limits for WWTF PSs that discharge directly to or upstream of lakes. MPCA adopted eutrophication standards for lakes in 2008, and it has refined its process for setting limits for WWTF PSs upstream of lakes since that time. Approximately 80% of the state's WWTF PSs currently discharge upstream of lakes that exceed Minnesota's lake eutrophication standards. Examples of impaired lakes with large watersheds such as Lake Pepin will be discussed later in this document. Many of these discharges are far upstream of a downstream impaired lake. Total maximum daily load (TMDL) studies have been started or completed for some of these eutrophication impaired lakes. These TMDLs have established upstream river goals for phosphorus (and chlorophyll-a in some instances) along with wasteload allocations for the upstream WWTF PSs that can be translated into TP WQBELs.

Regardless of whether a downstream water is impaired, WWTF PSs with reasonable potential to cause or contribute to an exceedance of a standard must have WQBELs in their NPDES permits. Given that there is a delay between data collection and water body assessment, there are times when WQBELs are required for discharges to waters for which there are adequate ambient data to determine reasonable potential even if the water has not officially been assessed or included on the state's 303(b) list of impaired waters.

Implementation of RES into effluent limits is different from the established process of setting WQBEL for more "traditional" pollutants such as conventional pollutants and toxics. The mass balance process in EPA's Technical Support Document for Water Quality-based Toxics Control (TSD) does not lend itself well to setting effluent limits based on eutrophication standards. The TSD is generally designed to protect the immediate receiving water during low flow conditions for a single pollutant that is typically well below standards upstream of the discharge. The RES are composed of both a cause variable (i.e. TP) and three possible response variables [i.e. chlorophyll-a(chl-a), biological oxygen demand (BOD)and daily oxygen fluctuation (DO flux)] (Table 1, Figure 1). Both TP and one of the responses variables must be exceeded downstream of a given discharge to trigger a WQBEL for RES assuming the discharge has reasonable potential to cause or contribute. Since TP is generally conservative, effluent limit setters will consider downstream resources even if designated uses are met at the immediate receiving water. RES are also based on a long-term summer average which is another unique facet of this water quality standard. All summer days and thus all summer flows are equally weighted when calculating a long-term summer average for RES. Evaluating a single summer river flow such as 7Q10 to establish effluent limits is not consistent with the definition of "average". All available flow data will be considered when establishing effluent limits for RES. Finally, phosphorus is ubiquitous in rivers from a variety of sources in any given watershed. Consideration of non-point source contributions and controls as well as the contribution from other point sources including other WWTF PSs and stormwater discharges will be included in WQBEL calculations. In order to achieve RES in many watersheds, reductions in TP from permitted point sources and unpermitted non-point sources will be required. Given the fact that the standard is meant to be applied as a long term (i.e. 10 years) seasonal average and the need to consider both the concentration in the discharge as well as the propensity of the receiving water to grow algae, the TSD approach to effluent limit setting is not practical nor true to the intent of RES. The approach that the MPCA proposes to use to calculate effluent limits for individual WWTF PSs is detailed in later sections of this document.

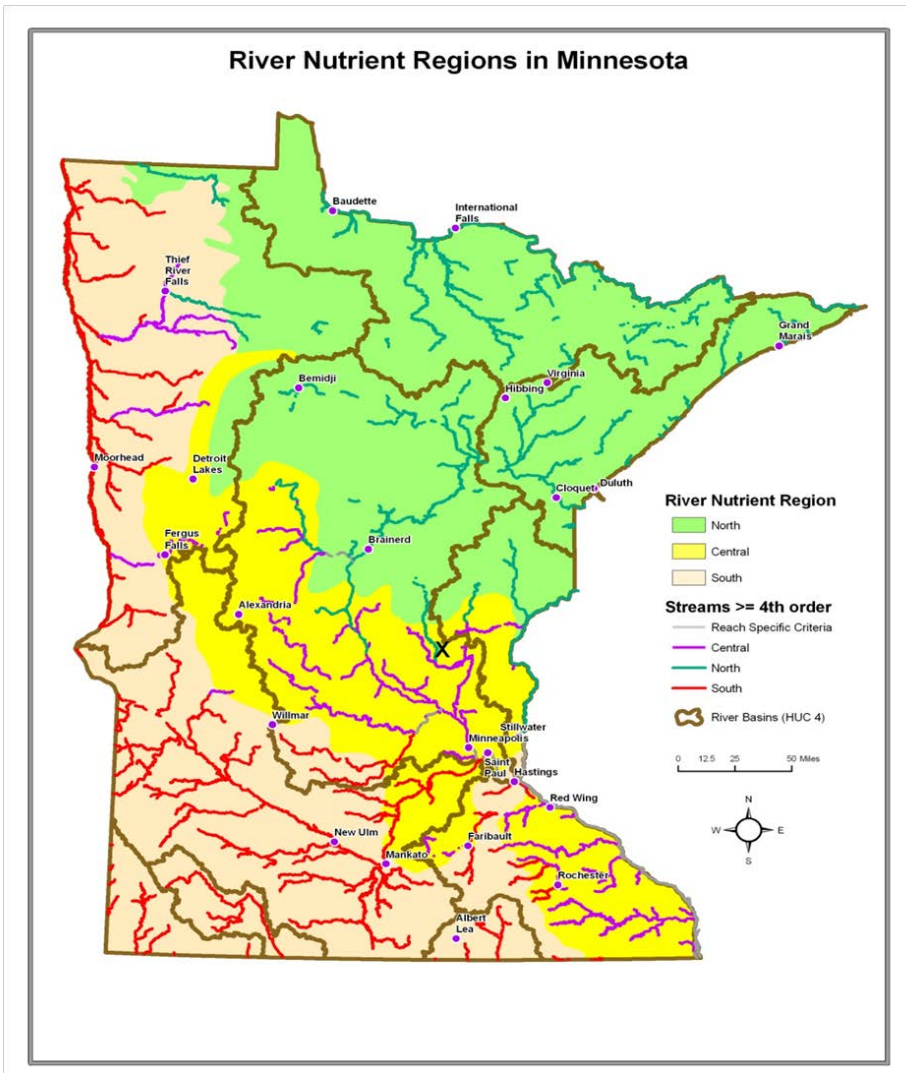
As part of the amendments to the eutrophication standards when RES were adopted, the MPCA also made a corresponding change to stream flow considerations when setting effluent limits (Minn. R. pt. 7053.0205, subpart 7, item C). This change was needed to account for the seasonal nature of the proposed river eutrophication standards. Minn. R. ch. 7053 pertains to the establishment of effluent limits and Minn. R. pt. 7053.0205 establishes the general requirements for discharges to waters of the state. Subpart 7 provides conditions for the consideration of minimum stream flow in the process of setting effluent limits. MPCA added a new item C to the requirements to address discharges of total phosphorus in relation to RES.

> Minn. R. pt. 7053.0205, subpart 7, item C: "Discharges of total phosphorus in sewage, industrial waste or other wastes must be controlled so that the eutrophication water quality standard is maintained for the long term summer concentration of total phosphorus, when averaged over all flows.
>
> When setting the effluent limit for total phosphorus, the commissioner is allowed to consider the discharger's efforts to control phosphorus as well as reductions from other sources, including non-point and runoff from permitted municipal stormwater discharges. "

Table 1. Eutrophication standards for rivers and streams in Minnesota.

	Nutrient	Stressor		
Region	TP mg/L	Chl-a µg/L	DO flux mg/L	BOD_5 mg/L
North	0.055	<10	≤4.0	≤1.5
Central	0.100	<20	≤4.5	≤2.0
South	0.150	<40	≤5.0	<3.5

Figure 1. Regions for river eutrophication standards.



The MPCA will determine reasonable potential and set WQBEL based on robust datasets including ambient TP, streamflow and response variable values. The MPCA uses an integrated watershed management (IWM) framework to monitor, assess and manage the state's water resources. The IWM framework includes the collection of ambient chemistry and streamflow at the outlets of all 81 watersheds in the state along with a number of upstream sites known as "10X" sites. It is important to target monitoring sites due to the considerable cost of monitoring streamflow and water-quality in rivers. Watershed outlets monitoring sites are typically located at a Hydrologic Unit Code (HUC) 8 sized watersheds except when a watershed includes a major river such as the Minnesota or Mississippi. There are extensive TP and streamflow data available for the watershed outlets since 2007 or 2008. Chl-a monitoring was initiated at these sites in approximately 2011. Some of these sites have extensive historical monitoring data from previous monitoring efforts administered by MPCA or other agencies. In many watersheds the watershed outlet sites are likely going to be the smallest river sites downstream of given WWTF PS with adequate monitoring data to complete the process described in this document. Existing data collected at the watershed outlets sites show that elevated TP can result in elevated suspended algal growth which results in exceedance of one if not all three of the response variables in RES. The watershed outlet sites are the cornerstones of watershed management in Minnesota and will be the focus of long-term monitoring in the state. Suspended algal levels are expected to be lower upstream of watershed outlet sites even if TP is elevated (S. Heiskary, MPCA Scientist). Thus, it is less likely for response variables to be exceeded in upstream streams and rivers.

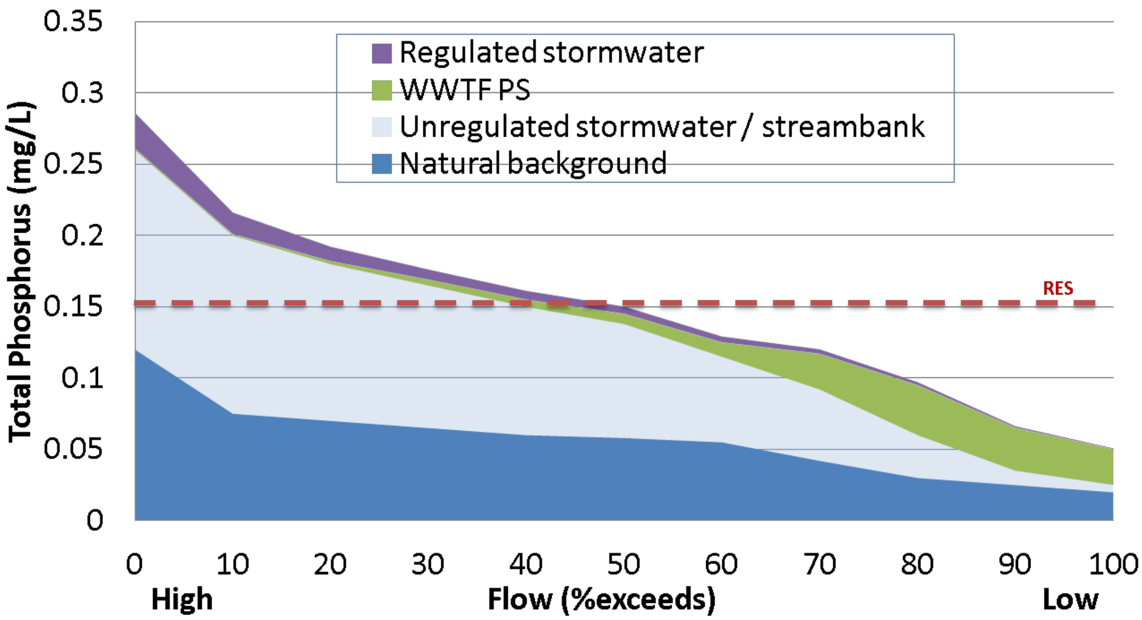
Monitoring data including response variables upstream of watershed outlet sites will be used to establish WQBELs when available. Datasets will preferably have a minimum of 2 summers of monitoring data with a minimum of 6 samples per summer. MPCA will evaluate receiving waters upstream of watershed outlet sites at selected "10X" sampling sites where adequate monitoring data exists. Approximately five 10X sites per watershed will be monitored for TP and chl-a for 2 summers. The monitoring schedule for the 10X sites rotates through the 81 watersheds on a 10-yr cycle. There will be some cases when data from sites upstream of the watershed outlet stations are not available. When available, data from 10X sites along with data from other sources will be used to inform permitting decisions. In cases where inadequate ambient data is available to determine whether a given WWTF PS has reasonable potential to cause or contribute to an exceedance of the receiving stream, additional monitoring may be required if justified. An individual WWTF PS may be required to conduct additional receiving water monitoring as a condition of its permit.

Consistent with the IWM to managing Minnesota's waters, MPCA will consider multiple WWTF PSs along with all other contributing sources within a watershed when setting WQBEL based on RES. Reduction of TP loading from non-point sources will be needed to meet RES in most watersheds that currently exceed RES. When non-point source loading, land use, and export coefficient information are available, MPCA will assume expected reductions in non-point sources based on watershed modeling efforts when calculating WQBELs. Existing data analysis indicates that in many of the watersheds that exceed RES in the southern, western and central part of the state would not meet RES even if all WWTF PSs met limits equivalent to RES end-of-pipe. Current eutrophication TMDLs for lakes and reservoirs have used a balanced approach to achieve targets. When setting WQBELs for discharges upstream of lakes, when appropriate, MPCA staff assume reductions will be needed by non-point sources. Similarly going forward, reductions in point and non point sources will be needed and assumed for limit setting purposes to protect designated uses and achieve RES.

Total phosphorus in rivers is often very dynamic as streamflow ebbs and flows. Generally, monitoring data indicates that TP increases with streamflow in watersheds throughout Minnesota. TP is relatively low during low flow except in watersheds with excessive point source loads. In rare cases such as below Heron Lake, internal loading from lake sediments can increase downstream river concentration during low flow. Analysis of concentration duration curves and composition of contributing sources will be imperative to identify the significance of WWTF PSs discharges to a given watershed. The extensive monitoring data at the watershed outlet stations for TP and streamflow discussed earlier allows MPCA to conduct this analysis. Graphically combining river monitoring data with WWTF PSs effluent data over all streamflows results in an informative image to assess the impact of hypothetical WQBELs for WWTF PSs in a hypothetical watershed in southern Minnesota to comply with RES(Figure 2). Much of this figure is based on results from modeling in the Cottonwood River Watershed. Model results were used to estimate contributions from regulated stormwater, unregulated stormwater / streambank, and natural background. These sources were reduced from original monitored levels based on modeled BMPs. It will be common to asses if downstream WQBELs such as a low-dissolved oxygen TMDL (where TP is associated with low dissolved oxygen) or lake TMDLs could also serve as a WQBEL for RES to protect designated uses of the more immediate receiving reach. For this example, point sources were included in the model at levels needed to achieve a downstream low-dissolved oxygen TMDL in the Minnesota River. The method for developing WQBELs for a low dissolved oxygen TMDL are different than the process described in this document since the former process only focuses on low flows during summer while the RES process considers all flows during summer. So in some situations the WQBELs for low dissolved oxygen and RES will not be equivalent as described here. Permitted loads from point sources are most significant from moderate to low flow (50-100% exceeds). The model also included transport losses of TP from all sources. Averaging all modeled concentration values for TP for 10 years reveals a concentration of 0.150 mg/L in the river. The ultimate goal of the limit setting process is to establish WQBELs for all WWTF PSs in a watershed that protect designated uses via numerical standards in the Cottonwood River (TP = 0.150 mg/L) and downstream resources (Minnesota river: TP 0.150 mg/L, lower Minnesota River dissolved oxygen = 5 mg/L and Lake Pepin TP = 0.10 mg/L) via the process briefly summarized here. Details regarding this process will be covered in the following section of this document.

Figure 2. Concentration duration curve of hypothetical watershed outlet station that meets 0.150 mg/L total phosphorus long-term average which is the RES of southern region. Figure represents contributions from

major sources to overall TP concentration at a given flow.



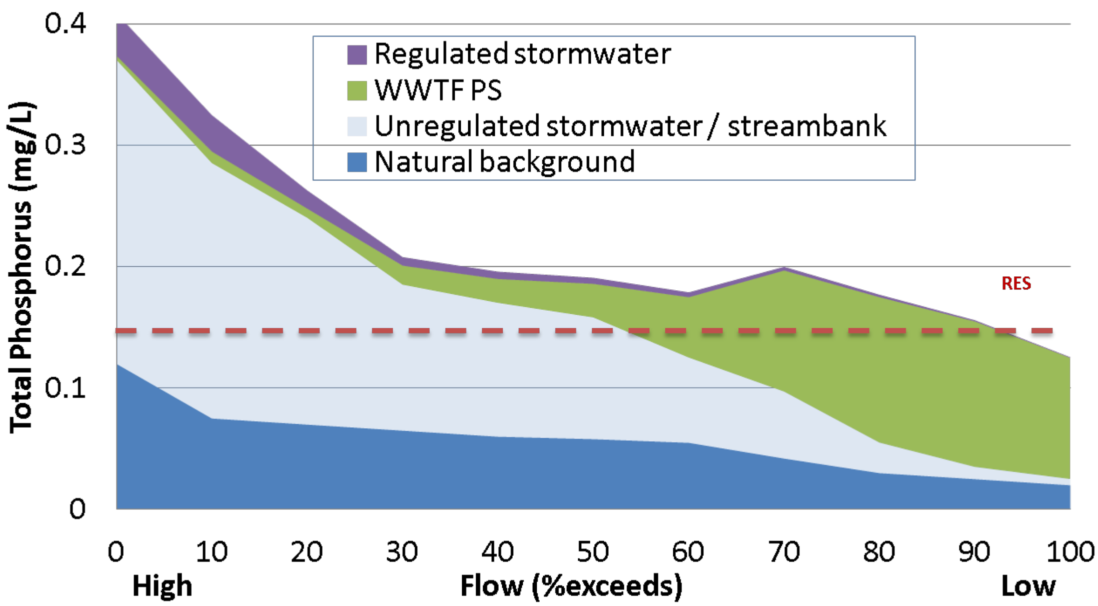
Reasonable Potential

This brief section will outline MPCA's approach to determining if a given WWTF PSs has the reasonable potential to cause or contribute to a downstream exceedance of RES. Since TP is generally conservative, the reasonable potential analysis will extend beyond the immediate downstream reach of a given discharge. If all receiving waters downstream of a given discharge do not exceed RES, then reasonable potential analysis is needed to determine if existing limits are protective of designated uses. Typically more restrictive limits will not be needed. In cases where facilities have substantial design flow that is not currently utilized a WQBEL may be more restrictive than current limits.

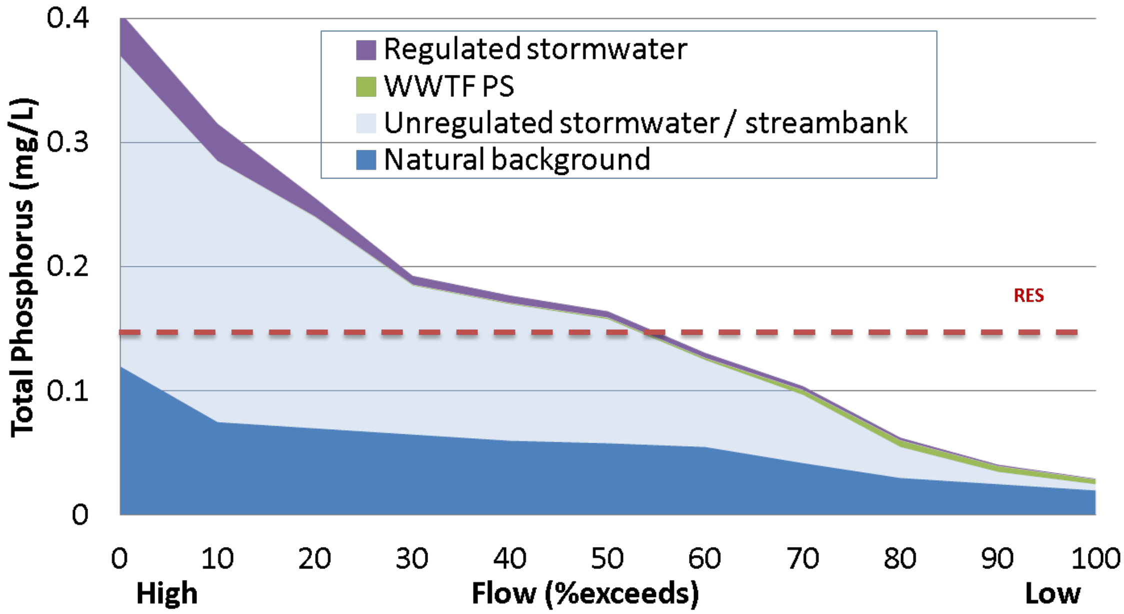
Reasonable potential analysis will be completed for WWTF PSs discharging at a concentration greater than the RES. The simplest test to determine if WWTF PSs in a given watershed contribute to a downstream exceedance of RES is to predict the TP concentration of a downstream river with WWTF PSs at current permitted levels verses the concentration of the same river with the WWTF PSs discharging at RES end-of-pipe (Figure 3). This example assumes that a response variable is also exceeded otherwise reasonable potential analysis would not be needed. The impact of reduced TP loads from WWTF PSs in this hypothetical example reduced the estimated long-term summer average TP in the river from 0.221 mg/L to 0.170 mg/L. The reduction in the predicted TP indicates that WWTF PSs in this watershed contribute to an exceedance of RES and therefore must receive WQBELs. If there was no change in the predicted river TP than the WWTF PSs would not contribute to the exceedance of RES. It is important to note in this example that the predicted river concentration of 0.170 mg/L still exceeds the RES of 0.150 mg/L due to the contributions from other sources in the watershed.

Figure 3. Concentration duration curve of a hypothetical river at its watershed outlet site that exceeds 0.150 mg/L long-term average total phosphorus RES of southern region. A) WWTF PSs at existing permitted load contribute to exceedance of RES in this watershed. Long-term summer average TP is 0.221 mg/L. B) WWTF PSs set at RES (0.150 mg/L) end-of-pipe to compare with graph "A" to determine if WWTP PSs contribute to the exceedance of RES. Long-term summer average TP is 0.170 mg/L.

A)



B)



Regulated stormwater
WWTF PS
Unregulated stormwater / streambank
Natural background
RES
Total Phosphorus (mg/L)
0.4
0.3
0.2
0.1
0
0
10
20
30
40
50
60
70
80
90
100
High
Flow (%exceeds)
Low

Watershed examples

The following watershed examples were selected to illustrate the real life implementation of RES into permits for WWTF PSs. The examples include discussion on the reasonable potential determination process and WQBEL setting considerations for facilities in different watersheds. Each watershed in the state is unique and the following examples are not exhaustive. However the considerations, data analysis, reasonable potential determination and limit setting process are applicable to watersheds throughout the state. Similarly WQBELs discussed in this document are not final, but they serve as a guide for the general range of limits that will be required in a given watershed. As access to technical tools improves and additional monitoring data is collected, MPCA will continue to refine our methods for calculating effluent limits to implement RES.

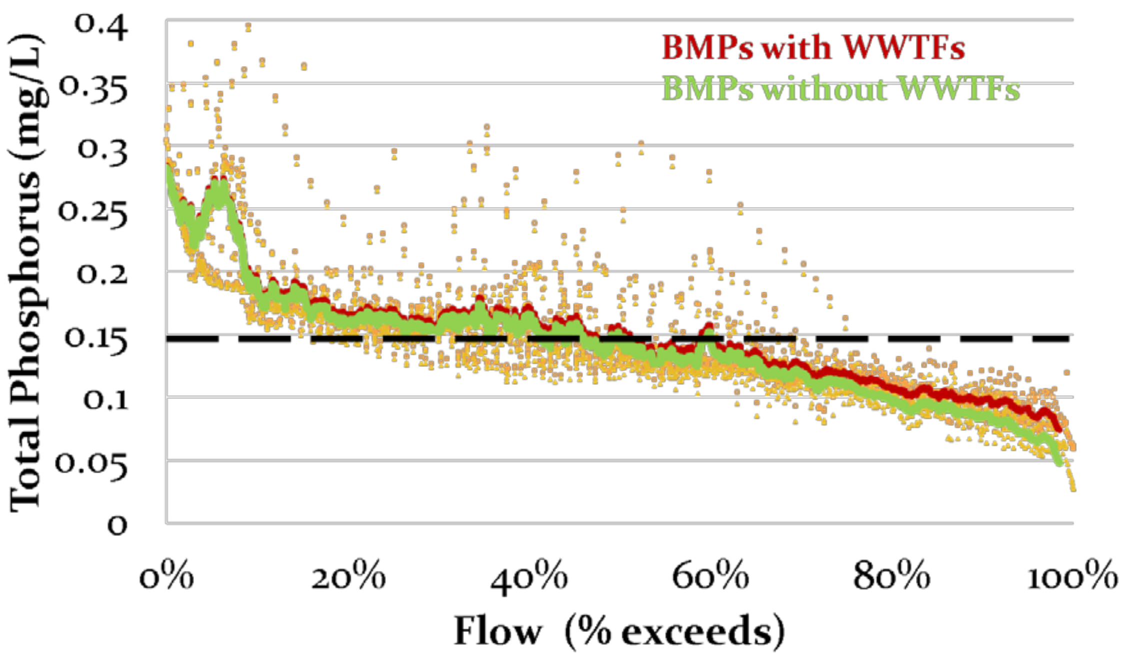
Cottonwood River near New Ulm

The watershed outlet monitoring site for the Cottonwood River near New Ulm is the preferred monitoring site to establish WQBELs for discharges in the Cottonwood River Watershed. There are some sites upstream of this site in the watershed, but these sites lack adequate data for the response variables of RES. The average summer concentration of total phosphorus (TP) in the Cottonwood River near New Ulm from 2000-10 was 0.168 mg/L which exceeds the RES of 0.150 mg/L for TP. The technique used to determine this average will be covered later in this section. Based on monitoring data from four summers from 2001 to 2009, chlorophyll-a in the Cottonwood River averaged 55 µg/L which exceeds the RES of 40 µg/L. MPCA must establish WQBELs for WWTF PSs in the Cottonwood River Watershed that have reasonable potential to “cause or contribute” to the exceedance of RES at the watershed outlet site.

Current model runs from HSPF indicate WWTF PSs in the Cottonwood watershed do not change the predicted TP in the Cottonwood River with WWTF PSs at 1 mg/L at actual flows (Table 3 for details) compared to WWTF PSs at 0.0 mg/L. Chlorophyll-a output of the HSPF model was not considered for this document, but it could be considered once the model is refined with new data. MPCA will update the HSPF model to include the permitted load which may increase the impact of point sources since the model runs above are based on actual historical flows which are typically less than permitted flows. For the purposes of this document we will assume that WWTF PSs do contribute to the exceedance of RES at the Cottonwood River watershed outlet. The continuous WWTF PSs could discharge 4.1 kg TP/day (anticipated WQBEL for Lake Pepin) at AWWDF. These same facilities would discharge 0.9 kg TP/day at AWWDF if their effluent concentration was at the RES of 0.150 mg/L. The difference between these two loading levels is very small compared to the overall loading in the Cottonwood Watershed. Transport losses in the watershed upstream of the watershed outlet station further limit the impact WWTF PSs in the Cottonwood River Watershed. Thirty-six percent of WWTF PSs’ flow in the Cottonwood River Watershed is from stabilization ponds (Appendix 1). Stabilization ponds typically discharge outside the June-September summer period which minimizes their impact on summer TP concentration in the river. Continuous discharges only account for 1.5 kg TP /day of the 4.1 kg/day total discussed earlier in this paragraph. It is difficult to detect any difference at the watershed outlet given the slight difference in the loads assessed here. Continuous WWTF PSs such as Sleepy eye and Springfield do discharge above the RES so there could be a contribution during low flows, however based on model runs it appears that attenuation in the river system is limiting the contribution of these facilities such that phosphorus discharged from these facilities does not reach the watershed outlet at a concentration greater than the RES based on a long-term average.

Similar HSPF model runs for the Minnesota River downstream of Mankato indicate that WWTF PSs upstream of this site do contribute to the exceedance of RES at this site (Figure 4). The percent contribution from WWTF PSs increase as streamflow in the river decreases. Based on available model runs, it is not possible to determine which WWTF PSs upstream of the modeled monitoring site contribute to the exceedance of RES. The model for the Minnesota River includes WWTF PSs in the Cottonwood River Watershed. Again, we will assume that WWTF PSs(s) in the Cottonwood River Watershed do contribute to downstream impairments for the purposes of this document even though the "contribution" to the Cottonwood and Minnesota Rivers is very slight.

Figure 4. Daily total phosphorus predicted by HSPF for the Minnesota River downstream of Mankato from 1993 – 2006 excluding 2000. Note TP data is arranged by flow (percent exceeds) for the Minnesota River based on the summer flow from 1993-2006.



Translating the HSPF model results for the Minnesota River into a management scheme requires some consistency for contributing watersheds if possible. The main channel of the Minnesota River exceeds TP and chlorophyll-a (Chl-a) throughout the Minnesota River (Mankato) Watershed. Based on a simple mass balance approach, all of the watersheds upstream of the Minnesota River (Mankato) Watershed need to be at 0.150 mg/L to protect the Minnesota River at Mankato. Reductions in the Mankato watershed itself will also be needed. This approach works well in this situation since all of the contributing watersheds are in the south river nutrient region (RNR) which corresponds to a RES of 0.150 mg/L for TP. The TP standard for the Minnesota River (Shakopee) downstream of the Mankato Watershed is also 0.150 mg/L. Current modeling results for Mississippi River Pools 2-4 (and some basic transport assumptions for Pools 5-8) indicate that a summer average concentration of 0.150 mg/L at the mouth of the Minnesota River would be sufficient to protect downstream waters assuming that all of the other tributaries to the Mississippi River also meet the reductions specified in the model runs. In summary, the Cottonwood River Watershed needs to achieve 0.150 mg/L TP long-term summer average to protect the Cottonwood River and downstream waters from exceeding RES.

The process for identifying sources of TP in the Cottonwood River and the contribution of these sources throughout the summer hydrograph were briefly discussed in the introduction of this document. The concentration duration curve in the introduction is a graphical representation for achieving RES in the Cottonwood River (Figure 2). The details behind the process will be discussed now.

MPCA has excellent TP data for the watershed outlet of the Cottonwood River. That being said, MPCA does not have continuous monitoring for 122 days each summer for 10 years (1,220 days total) at the watershed outlet site. A sampling program designed to sample this site during higher streamflow to improve estimated watershed loads collects about 15-20 TP samples per summer. TP generally increases with streamflow in the Cottonwood River. This data cannot simply be averaged to estimate long-term summer TP since it would be biased high. The watershed outlet sampling program does not have “routine” samples that are collected based on an equal interval sampling schemes such as bi-weekly sampling. Low flow samples are collected, but there is not a set schedule for these samples. MPCA has yet to develop a technique to estimate long-term averages from load based monitoring programs. One solution would be to use the calculated daily loads to estimate daily concentration for all summer days which can then be averaged to get a less biased estimate of long-term summer TP concentration. For the purposes of this document, the program FLUX from the U.S. Army Corps of Engineers was used estimate daily concentration estimates ($FLUX_{32}$ version 3.10). Estimated daily TP from FLUX are plotted as a concentration duration curve to validate the estimated values verses observed data and to illustrate the relation of flow and TP concentration in the Cottonwood River (Figure 5). Predicted values represent the average TP in the Cottonwood River throughout the summer hydrograph. This is how MPCA assessed that the long-term average TP of 0.168 mg/L is greater than the RES of 0.150 mg/L TP. The actual process for estimating long-term average TP from load based monitoring has not been finalized at this time and will likely depend on the availability of concentration and streamflow data at a given monitoring station. The FLUX based estimates presented here do represent the observed data well for this given river station (coefficient of variation = 0.081). Now that MPCA has a concentration duration curve we can examine the entire he summer to examine the impact of various sources on the exceedance of RES.

The entire summer dataset (actual and FLUX estimated) from the Cottonwood River for 11 years of extensive monitoring shows that total phosphorus does not exceed 0.150 mg/L during moderate to low flows (50% - 100% exceeds) (Figure 5). Concentrations of TP often exceed 0.150 mg/L from moderate to high flows (50% - 0% exceeds) when non-point sources are the dominant source of TP. Approximately 5 % of the annual load of phosphorus in the Cottonwood watershed is from point sources based on estimates from the SPARROW model (Figure 6). The SPARROW model was developed by the U.S. Geological Survey to evaluate sources of nutrients to rivers and the downstream transport of these nutrients. The model has been used extensively to estimate the delivered load of nutrients from states upstream of the Gulf of Mexico. The SPARROW model will be most useful for watersheds with little monitoring data, and it will be useful to assess downstream river transport in large river systems with a multitude of contributing watersheds.

Non-point sources are the dominant source of TP in the Cottonwood River Watershed. A load duration curve of the Cottonwood River further illustrates the small contribution of point sources during all flow conditions in summer (Figure 7). This figure plots the actual monitored load and includes the projected load of the river assuming the concentration is at the TP RES of 0.150 mg/L during all flows. Only at the lowest flow of the summer flows for the 11 years (2000-2011) used in the FLUX analysis does the load from the point sources in the watershed approach the load in the river that would be expected at the TP RES of 0.150 mg /L. Based on the existing monitoring data and FLUX estimated loads during low flows there are likely some transport losses at low flows. This is evident during very low flow (i.e. 95 to 100% flow exceeds) when the estimated watershed outlet load is less than the entire load discharged from the treatment plants. Otherwise, the measured load in the river would be slightly higher than WWTF PSs discharges during extreme low flows. Granted, it is possible that the WWTF PSs in the Cottonwood may have been discharging less TP than the assumed constant level of 5 kg/day. Based on this load analysis, maintaining existing WWTF PSs controls will also maintain acceptable TP concentration at low flows. The excessive TP loads occur from moderate to high flows where WWTF PSs loads represent from 5% to less than 1% of all loads, respectively.

Figure 5. Monitored and FLUX-estimated summer TP concentration verses measured streamflow for the Cottonwood River Watershed outlet site from 2000-2010. Flux estimates represent all summer days from 2000-2011.

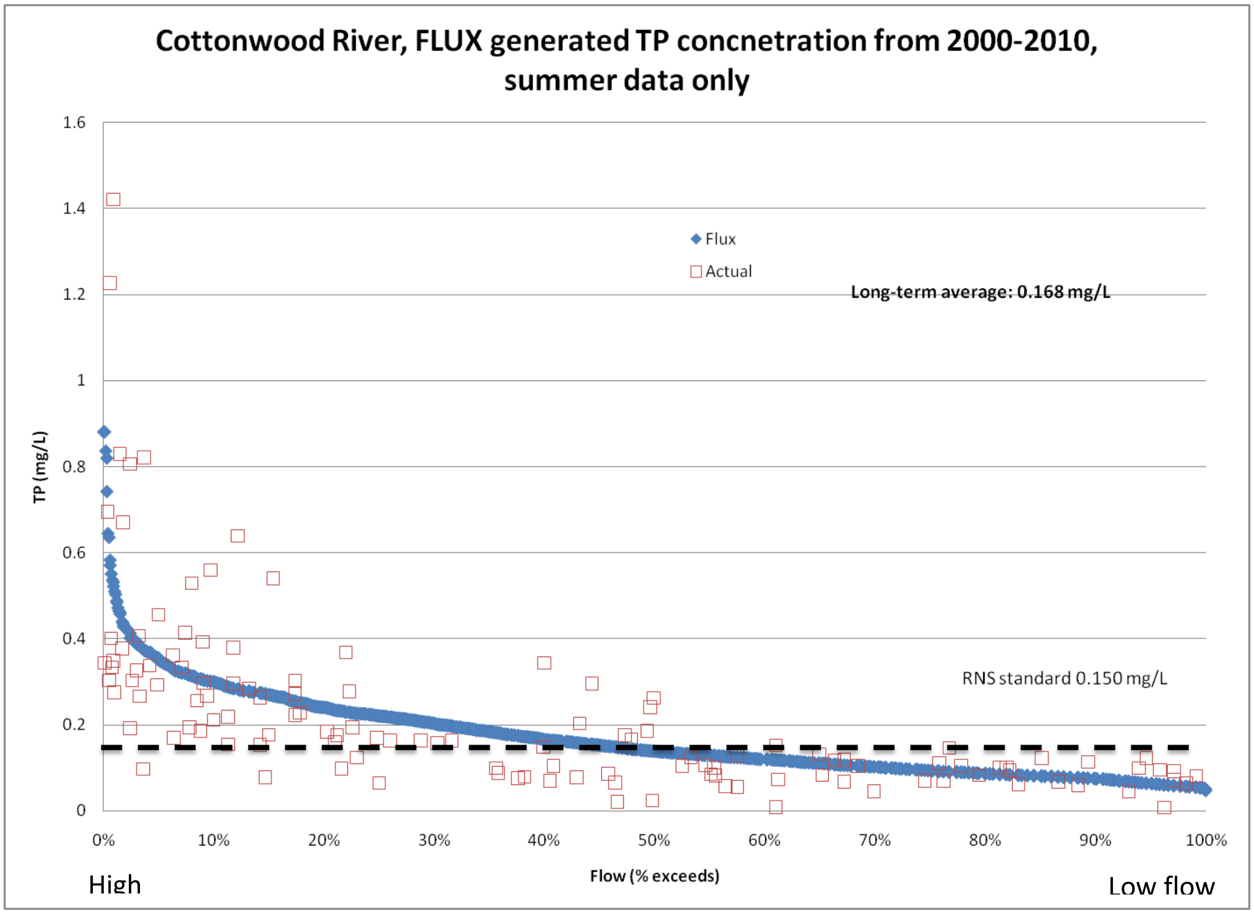


Figure 6. Estimated annual contribution of total phosphorus from various sources in the Cottonwood River Watershed during an average year. Point source loads reflect monitored data from 2002.

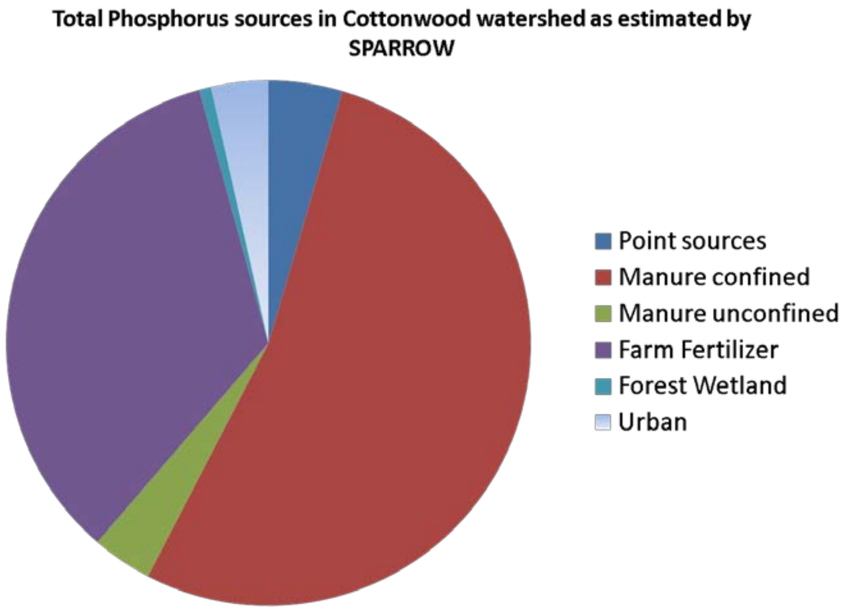
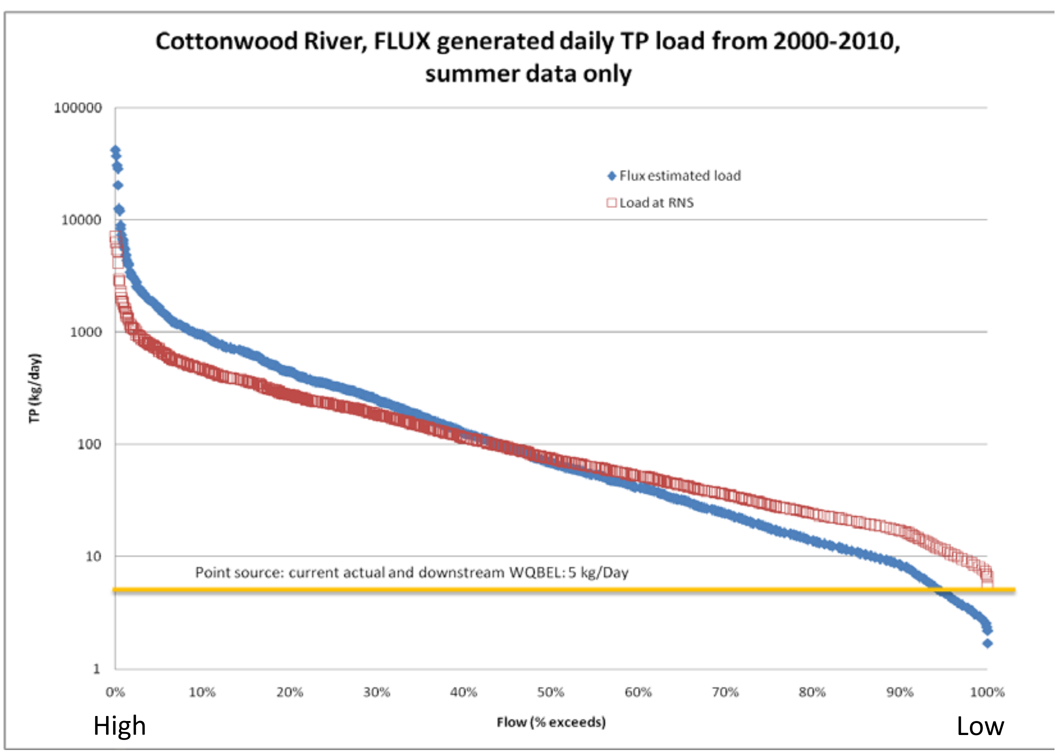


Figure 7. FLUX-estimated summer TP load verses measured streamflow for the Cottonwood River Watershed Outlet site from 2000-2010. Flux estimates represent all summer days from 2000-2010.



*Load at RES assumes load based on concentration of 0.150 mg/L at all flows, **Point source load represents historical load from continuous discharges and proposed WQBEL for downstream rivers

Non-point reductions within the Cottonwood R. Watershed will be essential to achieve RES and to protect downstream waters. Multiple lines of evidence show that non-point sources are the predominant source of TP in the Cottonwood River Watershed. To evaluate the contribution of non-point sources and WWTF PSs in the Cottonwood, MPCA staff considered available TP and chl-a data alongside long term flow data. Since non-point TP is the major source in the Cottonwood Watershed, MPCA needed a tool to evaluate non-point reduction scenarios. The HSPF model is an EPA-supported watershed model capable of incorporating both point and non-point sources along with routing nutrients to downstream reaches of concerns. MPCA along with its consultants have already spent significant resources calibrating and validating HSPF models. Fortunately, HSPF model calibration and scenario runs are available for the Minnesota River Basin including watersheds within the basin such as the Cottonwood.

There are eutrophication related concerns within and downstream of the Cottonwood River (Table 2, Figure 8). A low dissolved oxygen TMDL has been completed for the lower Minnesota River, and a draft turbidity TMDL for the Minnesota River and its major tributaries is in its final stages before public notice. Extensive modeling with HSPF was done for both of these TMDLs. TP is one of the modeled parameters available in the HSPF output. TP is often adsorbed to sediment particles that contribute to turbidity, so reductions in turbidity often result in lower TP levels. Reduction targets were based on achieving the MPCA's turbidity criteria. Anticipated TP requirements for WWTF PSs to achieve TP loading targets for Lake Pepin were also included in the modeling effort. HSPF is a dynamic model with daily TP outputs from 1993-2006 for all flow conditions. This is the best available model to estimate compliance with a seasonal standard that is averaged over a long period of time. HSPF or a similar dynamic model is preferred to a steady state model, and it will be used to estimate TP reductions for watersheds where modeling has been completed. Other advantages to HSPF include: ability to estimate the impact of various BMPs on non-points sources, ability to integrate multiple points sources along with non-points sources in a single model, and ability to route pollutants to downstream river reaches of interest (i.e. monitoring sites and or compliance points). Steady state models represent one flow condition which do not reflect the dynamic nature of TP in rivers which was considered as MPCA developed RES.

Table 2. Monitored condition for watersheds downstream of the Cottonwood River and anticipated approach to implementing river eutrophication standards. HSPF model outputs are available for all watersheds listed here except for Minnesota (Metro) and Mississippi River.

Watershed	TP > RES	Response > RES	TP RES (µg/L)	TMDL status	Comments	RES of 150 µg/L protective of downstream water[1]
Cottonwood R.	Yes (0.168)	Yes chl-a (56)	150	Needed for RES	Minnesota R., Pool 2-8 including Lake Pepin	Yes[2]
Minnesota R. (Mankato)	Yes	Yes	150	Needed for RES	High TP and Chl-a levels that will result in impaired status once RES become rule	Yes[2]
Minnesota R. (Shakopee)	Yes	Yes	150	Needed for RES	High TP and Chl-a levels that will result in impaired status once RES become rule	Yes[2]
Minnesota R. (Metro)	Yes	Yes	135	Completed	Effluent limits established for this low flow TMDL	Yes[2]
Mississippi River (Pool 2-8 including Lake Pepin)	Yes	Variable	100-125[3]	Developing site specific standards	Current modeling indicates that 150 µg/L at the outlet of the MN R. will protect downstream waters	Yes[2]

[1]This column identifies if the RES of 150 µg TP/L for the Cottonwood River is protective of downstream waters.

[2]The watersheds downstream of the Cottonwood watershed will need TP reductions in most of the contributing watershed to meet RES.

[3]Pool 2 and 3 have a higher standard than downstream resources. Wisconsin standard for Mississippi River is 100 µg/L.

Figure 8. Downtstream surface waters of the Cottonwood River including the Minnesota River and Lake Pepin that exceed RES. Stars indicate monitoring sites with excellent total phosphorus, chlorophyll-a and flow data.

MPCA will briefly discuss some of the results from the HSPF model runs completed for the Minnesota River Basin. This is important to demonstrate one technique of estimating non-point reductions which are essential to achieve RES in many of Minnesota's watersheds. As mentioned earlier, significant non-point reductions will be needed to meet the turbidity TMDL allocations for the Cottonwood River and Minnesota River. A baseline scenario and 5 reduction scenarios were completed with the HSPF model. Scenarios included a blend of point and non-point reductions (Tetra Tech 2009). Scenario 4 has been the focus of many public discussions regarding turbidity TMDLs in the Minnesota River Basin (Table 3, Figure 9) (personal communication Larry Gunderson, MPCA). The Minnesota River turbidity TMDLs ultimately used a load duration curve based approach, so it did not specifically identify which HSPF model run will be implemented on the landscape. The ultimate reductions required for the Minnesota turbidity TMDL will require reductions approximate to scenarios 4 and 5. Additional modeling runs to precisely achieve the turbidity standard and RES are not available at this time. So for the purposes of this document MPCA will take the average TP results of scenarios 4 and 5. The HSPF predicted baseline summer TP for 1993-2006 is 0.201 mg/L which exceed the RES of 0.150 mg/L TP (Figure 10). This is higher than the average TP estimated from FLUX discussed early, but the HSPF TP estimate is for a different set of years including high flow/TP years such as 1993 that increase the long-term average TP. Reductions scenarios are used to predict future conditions for future years with climate conditions similar to 1993-2006. The long-term summer average TP for years similar to 1993-2006 for scenario 4 is 0.159

mg/L which does not achieve the TP RES of 0.150 mg/L for the south RNR. Scenario 5 would achieve the RES with an average TP of 0.133 mg/L. The average concentration of Scenarios 4 and 5 is 0.146 mg/L which achieves RES. It is important to note here that even in scenario 5 some summers are predicted to have an average TP greater than 0.150 mg/L. This is acceptable and expected during high flow years as long as the long term average is below 0.150 mg/L.

Table 3. Summary of management strategies incorporated in Scenario 4 of Minnesota River Basin HSPF model.

HSPF Scenario 4 adjustments from baseline
Land Use: Increase pasture/CRP/ perennial crops plus forest to 20% of the watershed. Target areas near nickpoints, particularly in Blue Earth and Le Sueur. Achieve by reducing conventional tillage only. Increase Chippewa to 30%.
Cropping System 75 percent of row cropland with slopes greater than 3 percent use crop residue of 37.5 percent or greater. In addition, these lands have a cover crop to increase the spring cover. All surface tile inlets are eliminated. Nutrient management: follow U of M fertilizer recommendations. Manure management plans adjusted to nitrogen; full implementation of plans with setbacks from sensitive areas. 30% reduction in sediment from ravines due to use of drop structures, etc. 40% reduction in Blue Earth and Le Sueur
Upland Drainage Management Controlled drainage on crop land with < 1% slope (5/15-9/15) Two-stage ditch design Store 1” runoff for at least 24 hours.
Bank and Bluff Erosion Decrease maximum scour to simulate bank stabilization
Wastewater Discharges 1 mg/l TP for all mechanical facilities. Includes industrial discharges and stabilization ponds that are majors. If current limit is < 1 mg/L the lower limit is retained. Scenario 4a: Flow maintained from WWTF PSs, concentration set to 0.00 mg/L
Urban Stormwater Infiltrate the first inch of runoff from both impervious and pervious urban surfaces.
Baseflow Sediment Concentration Remove “extra” sources.

Figure 9. Existing land use and HSPF scenario 4 land use for the Cottonwood River Watershed.

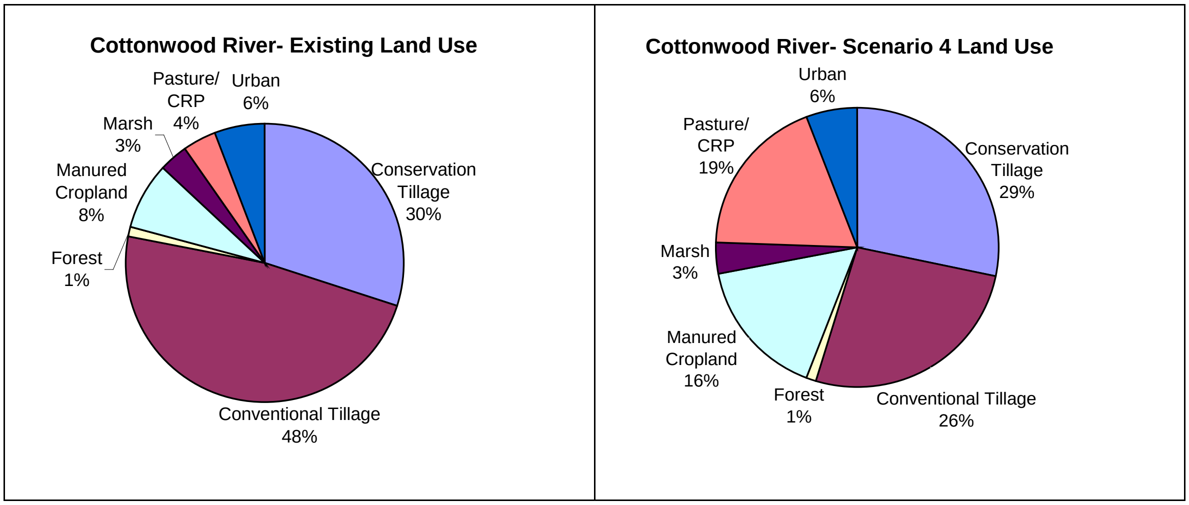
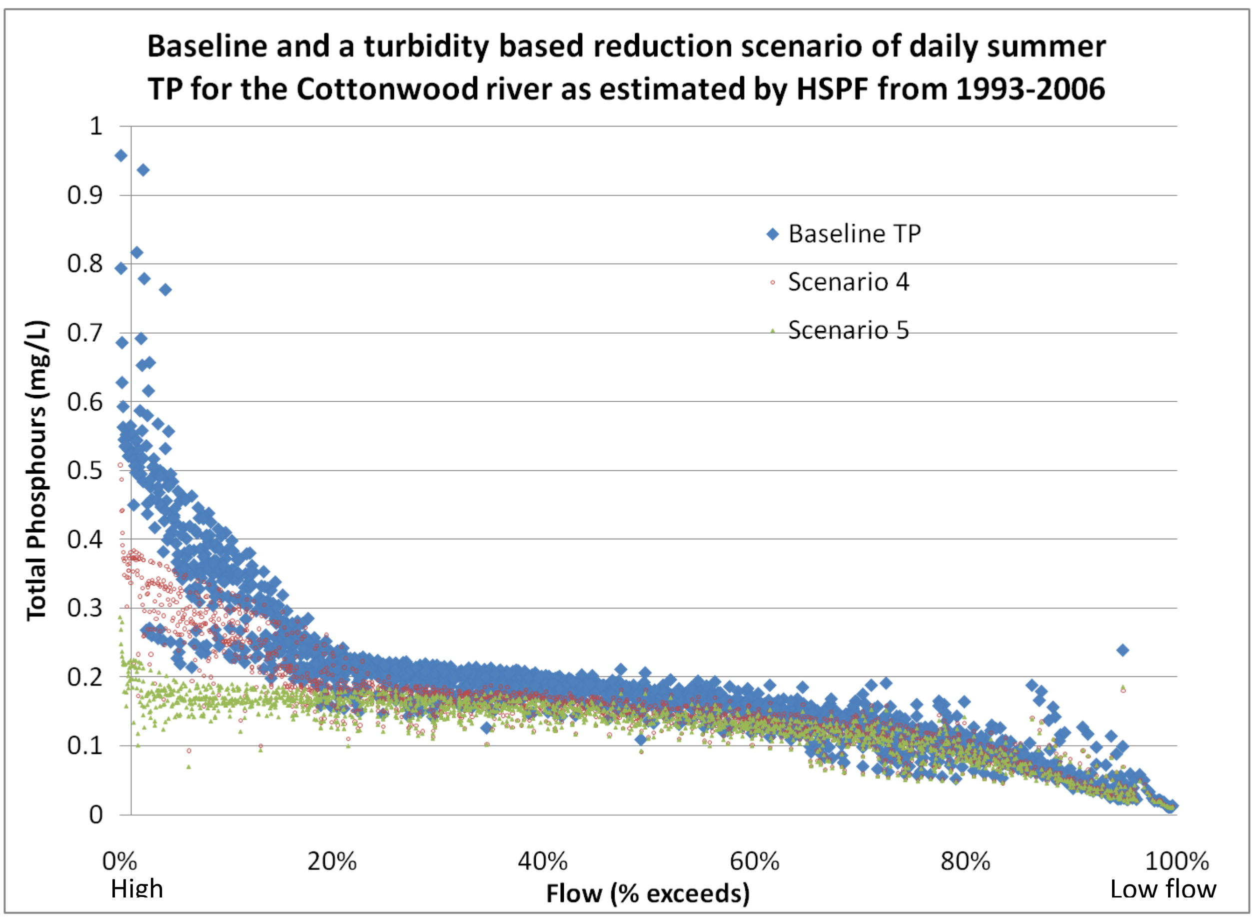
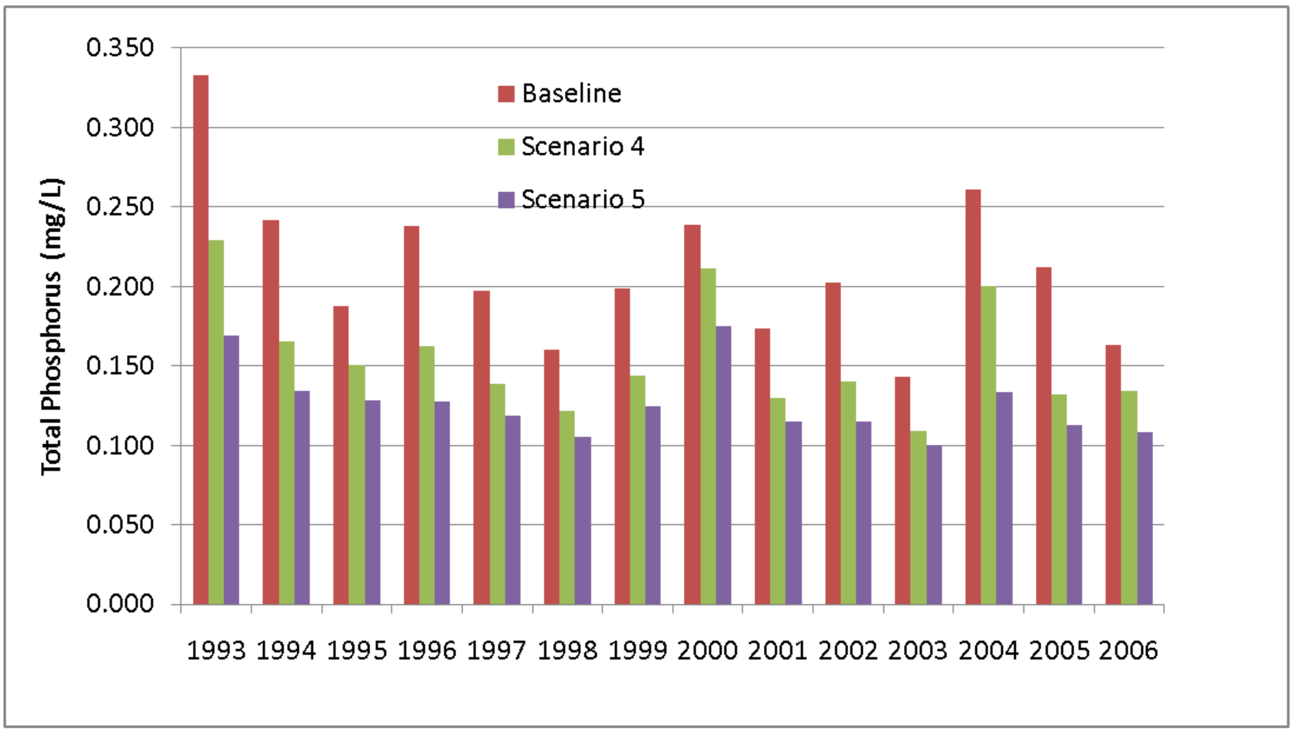


Figure 10. Daily total phosphorus predicted by HSPF for the Cottonwood River at New Ulm from 1993 - 2006. Note TP data is arranged by percent exceeds flow of the Cottonwood River based on the summer flow from 1993-2006.



The first downstream resource of the Cottonwood River is the Minnesota River (Mankato) which currently does exceed both the cause variable (TP) and response variable (chl-a) of RES. There is also HSPF output data for this river reach. The TP RES be achieved between scenario 4 and 5 (Figure 11). MPCA would already consider that the Cottonwood River would be acceptable between scenarios 4 and 5 since it achieves the 0.150 mg/L goal of the immediate watershed. The results for the middle Minnesota River are discussed here to illustrate that the downstream resource would also meet the proposed river standards. This is assuming reductions between scenarios 4 and 5 for all of the watersheds upstream of and within the middle Minnesota River.

Figure 11. HSPF predicted summer average for the outlet of the Minnesota River (Mankato) Watershed from 1993 - 2006. Scenario 4 and 5 represent various degrees of non-point reductions with a consistent allocation for point sources.



Using the available ambient TP, chl-a, and flow information, in addition to FLUX, SPARROW, and HSPF model results, MPCA staff were able to evaluate whether discharges to the Cottonwood have reasonable potential to cause or contribute to an exceedance of the RES in the Cottonwood River watershed and downstream watersheds. The general working assumption is that most point sources discharging during the summer at a concentration greater the 0.150 mg/L TP do contribute to an exceedance of RES in the Cottonwood River. This is often true in watersheds with few if any lakes between WWTF PSs discharges and monitoring sites used to assess RES. The analysis discussed in this section resulted in development of WQBELs included in Table 4. The analyses in this document may be updated if new data exists to calculate final WQBELs. These limits approximately reflect the point sources discharges included in existing HSPF model scenarios. MPCA has considerable experience with establishing effluent limits for watersheds with nutrient impaired reservoirs and lakes. Not all WWTF PSs in a given watershed contribute equally to elevated TP in downstream waters. To maintain consistency throughout the state when establishing WQBELs, MPCA has set WQBELs based on the degree that individual WWTF PSs "contribute" to impairments. Limits are based on a basin-wide strategy to meet RES at the Cottonwood River Watershed Outlet and downstream waters including the Minnesota River and Lake Pepin. These draft limits will achieve a long-term summer average of 0.150 mg/L TP in the Cottonwood River once non-point reductions are made in the watershed. In the near term, these limits will protect the Cottonwood River during moderate to low flows when WWTF PSs have the most potential to impact TP concentration in the Cottonwood River. Table 4 illustrates one potential way to equitably establish WQBELs for the facilities in the Cottonwood. The limits are based partly on the extent to which a given facility contributes TP to the watershed.

Table 4. Draft limits for facilities in the Cottonwood watershed to comply with proposed river eutrophication standards.

Facility (AWWDF or MDF)	**Concentration to meet Cottonwood RES**	**Concentration limit to meet downstream RES in Minnesota River**	**Concentration to meet low dissolved oxygen TMDL in metro Minnesota River**	**Concentration limit to meet Lake Pepin targets**
Continuous > 1.0 mgd	0.8	0.8	Mass limits, final limits TBD, May-Sept only	0.8
Continuous 0.2 – 1.0 mgd	1.0	1.0	Mass limits, final limits TBD, May-Sept only	1.0
Continuous <0.2 mgd	Maintain current discharge*	Maintain current discharge*	Maintain current discharge*	Maintain current discharge*
Stabilization ponds	Maintain current discharge*	Maintain current discharge*	Maintain current discharge*	Maintain current discharge*
Facilities at conc. Below RES	Maintain current discharge**	Maintain current discharge**	Maintain current discharge**	Maintain current discharge**

*Mass limits froze

**Expansion of these facilities may be permitted assuming effluent concentration remains below RES

South Fork Crow River Watershed

The analyses completed for the South Fork (SF) Crow River Watershed are not as comprehensive as that of the Cottonwood River. HSPF model results are not available for the SF Crow Watershed, but they were being developed. This example will not cover all aspects of MPCA's process for establishing RES WQBELs to avoid redundancy of topics covered in the Cottonwood River Watershed example.

The South Fork of the Crow River clearly exceeds RES for the south RNR for both the cause variable (0.150 mg/L TP) and response variable (40 µg/L chl-a) with observed summer averages of 0.395 mg/L and 102 µg/L, respectively (Figure 12, Table 5). Unlike the Big Fork and Cottonwood Watersheds, point sources are a significant source of TP in the watershed. Non-point loads are also high so this watershed represents a challenging scenario where both point and non-point sources of TP are significant. MPCA examined key moderate to low flow conditions to assess the impact of point sources in this watershed. This analysis was completed for the purposes of this document and is not the final product that will be used to set effluent limits in the South Fork of the Crow Watershed. Point source loads have been dramatically reduced in the watershed the past few years. Updated monitoring data from both WWTF PSs and the watershed outlet monitoring station will be used to calculate effluent limits.

Figure 12. FLUX generated summer total phosphorus of the SF Crow River from 2000-2010.

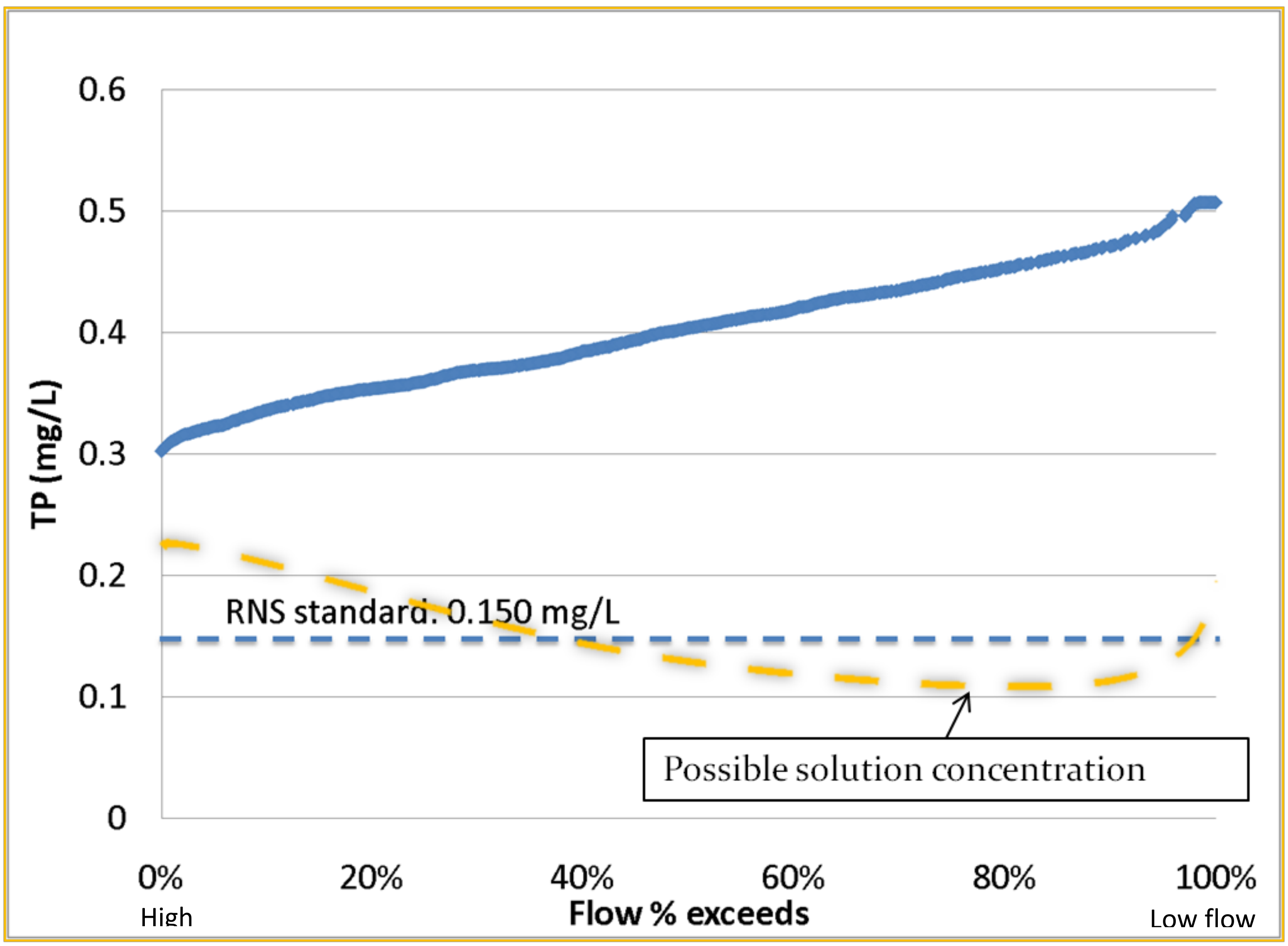


Table 5. Monitored condition of the South Fork Crow River and downstream watersheds and anticipated approach to implementing river eutrophication standards.

Watershed	TP > RES	Response > RES	TP RES (µg/L)	TMDL status	Comments	RES of 150 µg/L protective of downstream water[1]
South Fork Crow	Yes	Yes	150	Years after RES become rule	Minnesota R., Pool 2-8 including Lake Pepin	NA
Mississippi R. (at Anoka)	Yes	Yes	100	Not Listed	High TP and Chl-a levels that will result in impaired status once RES become rule	Yes[2]
Mississippi R. (Lock and Dam 1)	Yes	Yes	NA	Not Listed	High Chl-a levels that will result in impaired status once RES become rule	Yes[2]
Mississippi River (Pool 2-8 including Lake Pepin)	Yes	Variable	100[3]	Developing site specific standards	Current modeling indicates that 100 µg/L at LD 1. will protect downstream waters	Yes[2]

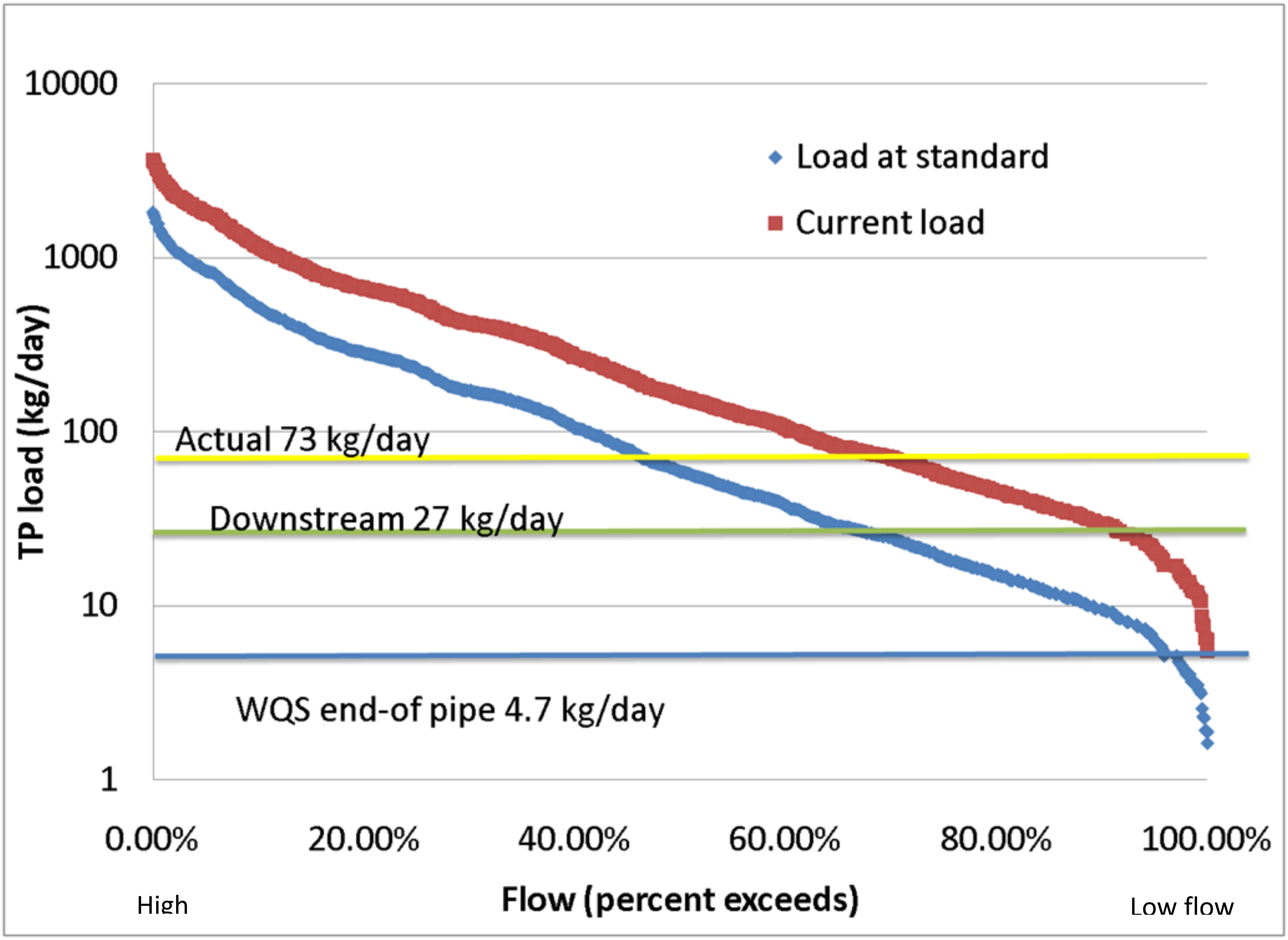
[1]This column identifies if the RES of 150 µg TP/L for the South Fork Crow River is protective of downstream waters.

[2]Additional watersheds in the Minnesota River Basin will also need reductions to meet RES.

[3]Lake Pepin is the only resource in this reach with a specified TP RES. The pools have Chl-a RES only. All of these standards are draft at this point.

The combined load to the South Fork Crow River from all sources is currently above a calculated “load at standard” line during all flow conditions (Figure 13). The “load at standard” line assumes that the concentration of the SF Crow River will always be at 0.150 mg/L however, river concentration is much more likely to vary based on flow as shown in Figure 12 (possible solution concentration). The “possible solution concentration” line in the concentration figure includes the following considerations: point sources will be allowed to increase the concentration of the river above RES for the lowest flows, high flow levels of TP will likely remain above 0.150 mg/L even after dramatic non-point reductions, and the concentration is below 0.150 mg/L during moderate to low flows when algae are most likely to respond to phosphorus. The line discussed here is based on MPCA’s current understanding of algal response in rivers. MPCA’s expertise should continue to expand in the future with more monitoring and modeling efforts.

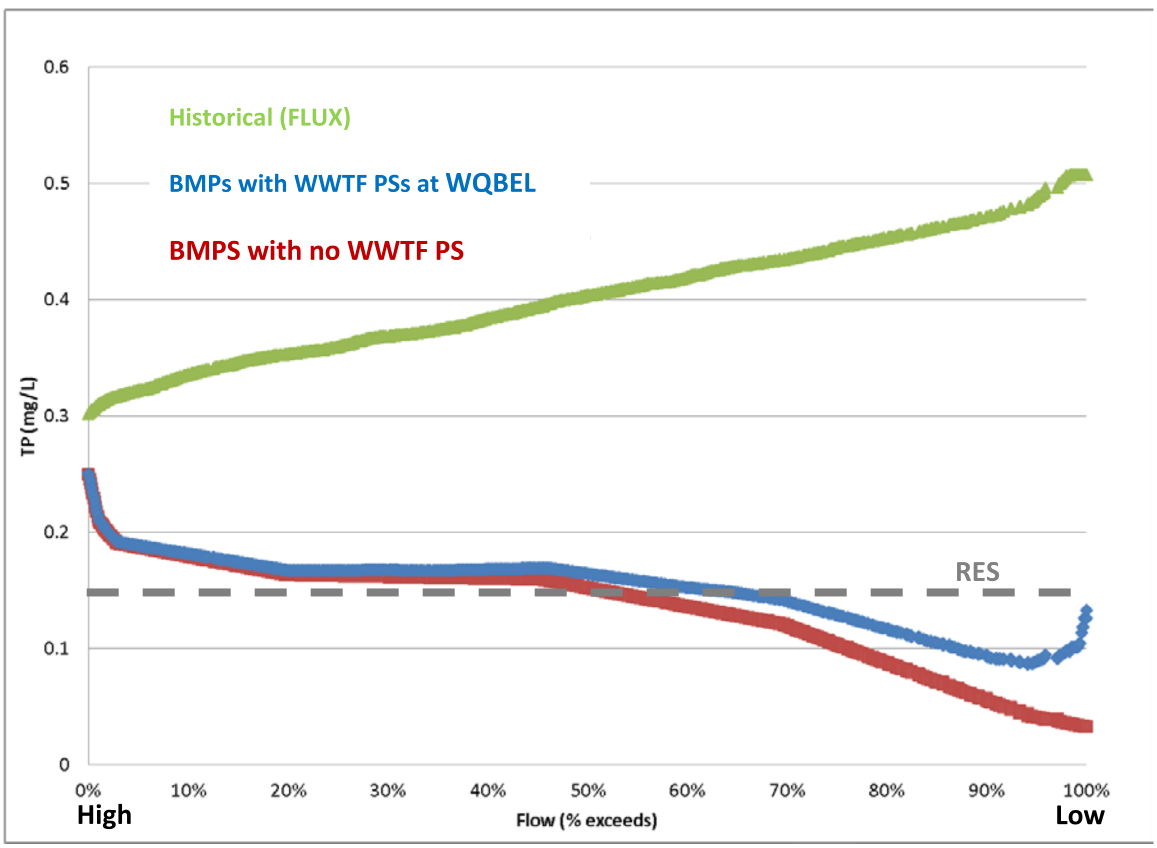
Figure 13. Current load based on FLUX and load assuming 0.150 mg/L concentration at all flows. Labeled horizontal lines indicate various loading rates for continuous discharges in the SF Crow watershed.



Actual = Monitored WWTF PSs load from 2005; Downstream = WWTF PSs load at AWWDF to comply with draft allocations for Lake Pepin; WQS end-of-pipe = WWTF PSs loads assuming all facilities are discharging at AWWDF and 0.15 mg/L with some modest transport losses.

A future vision of SF Crow River was developed to estimate permit limits for this document. The limits required to meet RES for facilities in the SF Crow are lower than the current limits in the watershed due to the large load from point sources contributing to elevated TP concentrations during moderate to low flows. Dilution and transport losses of WWTF PS loads may meet downstream allocations for resources such as Lake Pepin, but current analysis indicates that it does not meet RES in the SF Crow River Watershed. A future concentration duration plot for the SF Crow was developed to evaluate the load from point sources that could be allowed in the watershed (Figure 14). Assumed transport losses from WWTF PSs for this exercise that ranged from 75% loss at the lowest flows to 0 % loss at the highest flows. The projected long-term summer average of best management practices (BMPs) for non-point sources without point sources is 0.133 mg/L. This is based on model runs for the Cottonwood River where non-point reductions are the predominant issue. Next MPCA added various watershed WWTF PS loads to the future baseline to determine what level of discharge could meet RES. Loads based on downstream RES of the Mississippi River and lake targets such as Lake Pepin would allow for 27 kg/day from continuous discharges in the SF Crow watershed. This load is expected to maintain the concentration of the SF Crow above 0.150 mg/L for all flows. The "BMPs with WWTF PSs at WQBEL" is based on a load of 10.5 kg/day. This would result in a long-term summer average TP of 0.150 mg/L and protect the river from high TP concentrations during moderate to low flows when algal response is most likely. Additional refinements in transport losses and background TP will be completed with additional monitoring and modeling efforts as MPCA implements RES. Concentration effluent limits equivalent to the RES end-of-pipe (0.15 mg/L as concentration, 4.7 kg/day as a cumulative mass for continuous discharges in the watershed) would dramatically reduce the point source contribution in the SF Crow and serves as an example of the most restrictive limits that could be calculated for this watershed. Calculations to determine the final limits for this watershed will consider the following: land use in the watershed, contributions from WWTF PSs, other permitted point sources including MS4s and industrial stormwater, non-point sources, reductions from all contributing discharges, background concentrations at moderate to low flows, fate and transport of TP instream, available modeling tools, and best professional judgment (Table 6, Appendix 2).

Figure 14. Predicted concentration of the SF Crow River after implementation of non-point BMPs with and without WWTF PSs along with historical concentration verses summer flow exceeds.



*This figure is a general example to the approach for watersheds in southern MN.

Table 6. Draft limits for facilities in the South Fork Crow River Watershed to comply with proposed river eutrophication standards.

Facility (AWWDF or MDF)	Concentration to meet SF Crow RES	Concentration limit to meet Mississippi River RES	Concentration limit to meet Lake Pepin targets
Continuous > 1.0 mgd	0.15-0.5 **	0.8	0.8
Continuous 0.2 – 1.0 mgd	0.15-0.5**	1.0	1.0
Continuous <0.2 mgd	0.15-1.0**	Maintain*	Maintain*
ponds	Maintain*	Maintain*	Maintain*

*Mass limits froze

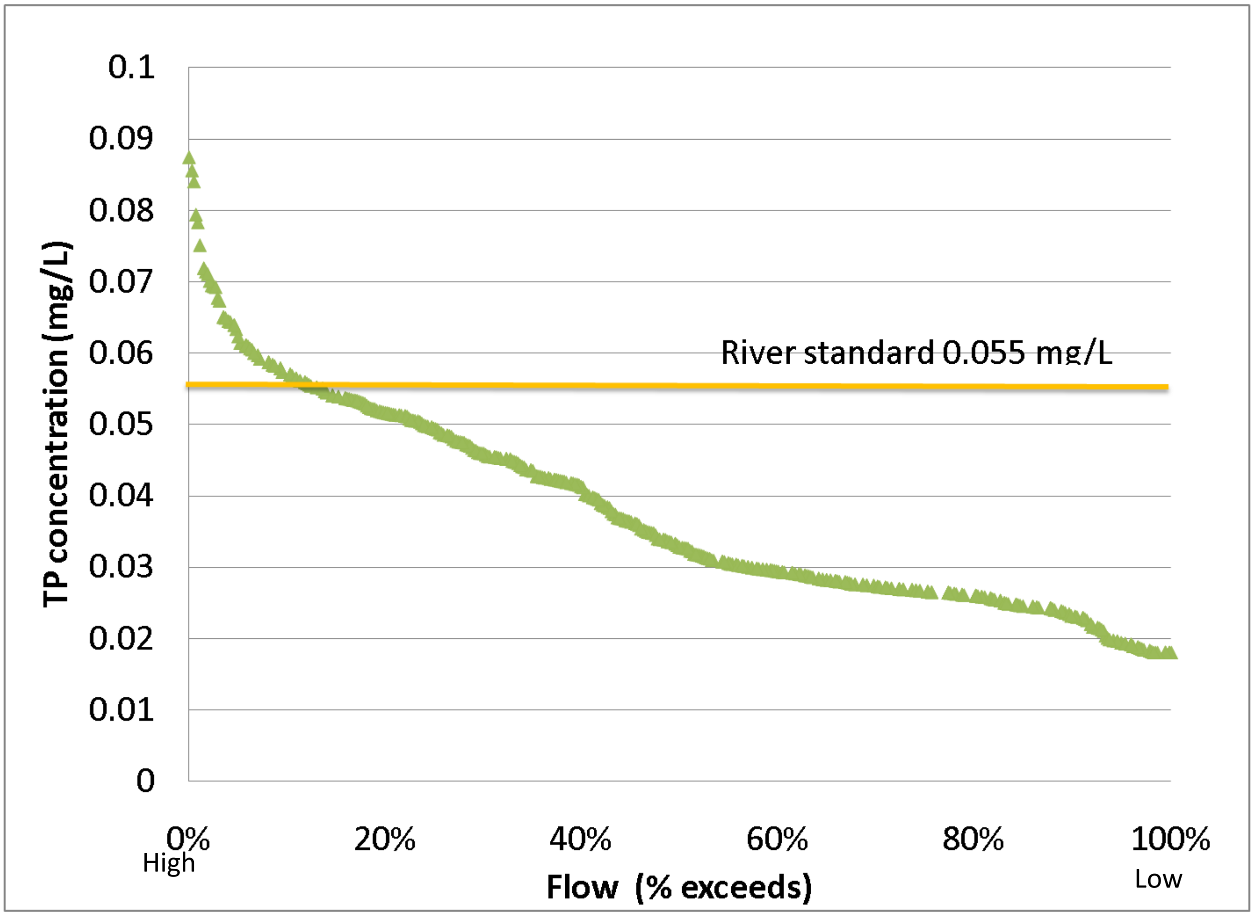
** Final limits will depend on final calculations for dilution, non-point reductions and transport losses

Big Fork River Watershed

The Big Fork River represents a relatively simple watershed in terms of implementing river eutrophication standards. From 2007-10, this river averaged 0.038 mg/L TP (Figure 15). This low level is important for two reasons. First, it is below the RES in the northern RNR and generally indicates that permitted points sources in the Big Fork watershed are at acceptable levels at current discharge levels. Second, it is also likely below any inflow target that will be developed for Lake of the Woods. This is significant since Lake of Woods is impaired for eutrophication and the TMDL for this resource has not been completed.

One critical tenet of MPCAs watershed approach is not only fixing impaired waters, but also protecting watersheds that meet WQS. The Big Fork River watershed is well below the TP threshold for RES and should not need any reductions in point or non-point sources. Complicated modeling for effluent limits is not required since MPCA has a “real-world” model where existing land-use practices and point sources result in desirable nutrient levels in the river of concern. Lake of the Woods is located downstream of the Big Fork Watershed, and it does not meet designated uses based on lake eutrophication standards. Initial analysis for improving Lake of the Woods indicates that it will be important to maintain existing loads from the Big Fork River Watershed along with implementing some point sources reductions for larger facilities discharging directly to the Rainy River (Table 7). Antidegradation and/or federal regulations for discharges upstream of impaired waters will be applicable to new or expanding discharges in the Big Fork watershed since it upstream of Lake of the Woods.

Figure 15. FLUX-estimated summer TP concentration verses measured summer streamflow for the Big Fork River Watershed outlet site from 2007-2010. Flux estimates represent all summer days from 2000-2011.



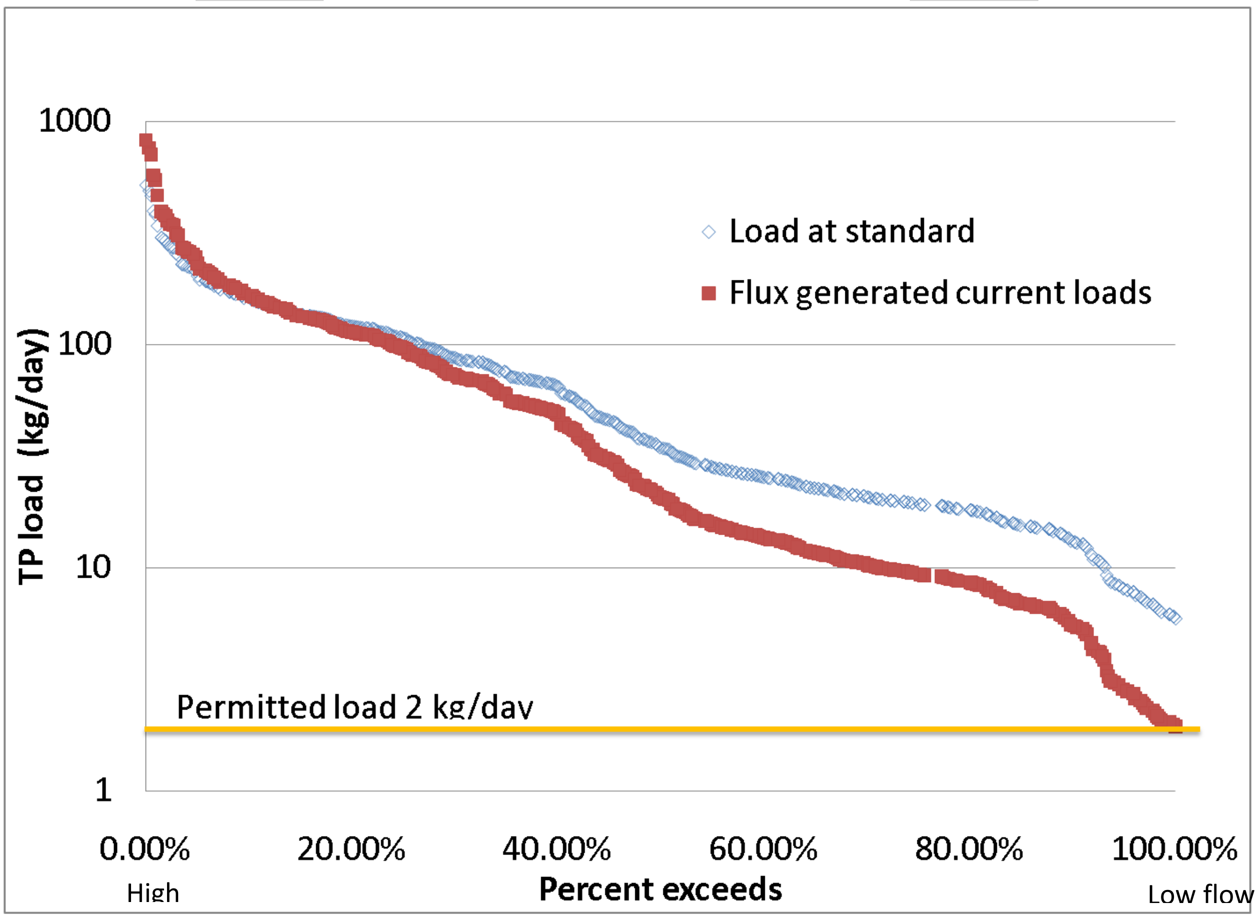
A permitted load of 1.15- 2.0 kg/day from WWTF PSs assuming 100% transport would only approach the monitored load in the Big Fork River Watershed at the lowest monitored summer flows (Figure 16, Appendix 3). The permitted load would only be 0.40 kg/day during summer if the three pond facilities in the basin did not discharge during the summer months. The lack of a large "unused" permitted load in the Big Fork River Watershed is further justification to limit modeling efforts in this watershed for WWTF PSs TP effluent limits.

Table 7. Monitored condition and anticipated approach to implementing river eutrophication standards for SF Crow and downstream watersheds

Watershed	TP > RES	Response > RES	TP RES (µg/L)	TMDL status	Comments	Current concentration protective of downstream water[1]
Big Fork River	No	No	55	Not needed	Much better than RES	Yes[1]
Rainy River	No	No	55	Not needed	Limited data	Unknown[2]
Lake of the Woods	Yes	Yes	30	In progress	Complicated resource, impaired in southern portion of the lake	Yes[3]

[1]Current estimated conentration of Big Fork River is 38 µg/L.
[2]Lake of the Woods TMDL has not developed a concentration target for the Rainy River.
[3]Lake of the Woods has sufficient residence time to trap most nutrients before they are transported to downstream resources.

Figure 16. FLUX-estimated summer TP load verses measured streamflow for the Big Fork River Watershed Outlet site from 2000-2010. Flux estimates represent all summer days from 2000-2010.



Statewide considerations

Lakes and Reservoirs with significant tributaries

Lake standards were promulgated in 2008 and listing of lakes on the 303(d) list started in 2002 based on narrative standards. Lake standards are lower in terms of TP than the proposed RES. This is discussed extensively by Heiskary et al (2010). Five hundred twenty-seven lakes or individual bays of lakes are listed as impaired waters for eutrophication in 2012. The contributing watersheds for these eutrophication impaired lakes and reservoirs are extensive (Figure 17). Regardless of the timeline of RES, the TP concentration of many of the state's rivers will need to be reduced to meet lake standards. Ultimately, achieving lake standards will result in a lower TP concentration in streams and rivers entering and exiting impaired lakes. The following list includes many of the impaired lakes that are closely tied to conditions of upstream river in terms of input phosphorus concentration and load due to short hydraulic detention times (Table 8).

Figure 17. Watersheds for impaired lakes and reservoirs in Minnesota.

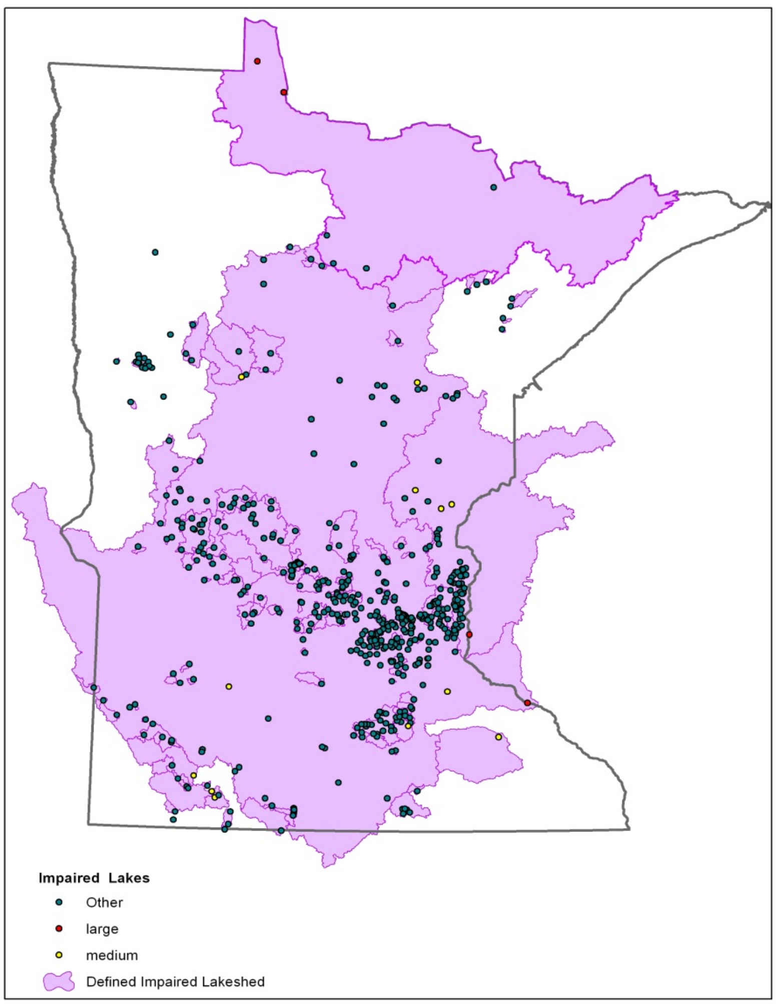


Table 8. Eutrophication impaired lakes and reservoirs with large tributary rivers in Minnesota.

Impaired Lake	Basin tributaries	Watershed tributaries
Pepin	Minnesota, Upper Miss., St.Croix	33
Lake of the Woods	Rainy	7 in MN
St. Croix	St. Croix	4 in MN
Zumbro		Zumbro River
Byllesby		Cannon River
Big Sandy		
Horseshoe Chain		Sauk River
Heron		
Cross		Snake River
Knife		
Lac qui Parle		2 in MN
Lower Minnesota River low DO TMDL		10

MPCA is also in the process of or has completed many turbidity TMDLs which will result in significant reductions in non-point loads of phosphorus. There have also been total phosphorus reductions that have been required by low dissolved oxygen TMDLs like the lower Minnesota River and Long Prairie River. Reductions such as these will be considered when settling effluent limits to comply with RES.

Impacts of nutrients upstream of watershed outlet sites

This brief section provides background regarding the anticipated response of elevated TP in rivers upstream of watershed outlet stations. MPCA does not anticipate abundant suspended alga in headwater streams (Figure 18). Periphyton is an assemblage of algae attached to substrate in streams and smaller rivers. Light often penetrates to the bottom of these streams which provides sufficient light to drive photosynthesis. Periphyton can be present in excess amounts which negatively impacts the biological community of the stream. MPCA's standard for periphyton is 150 mg/m^2. MPCA will go through a stressor id process to determine the cause of the excess periphyton. Until the cause is determined via the stressor id process, effluent limits for a WWTF PSs discharging to a stream with excess periphyton will be determined in order to protect downstream waters.

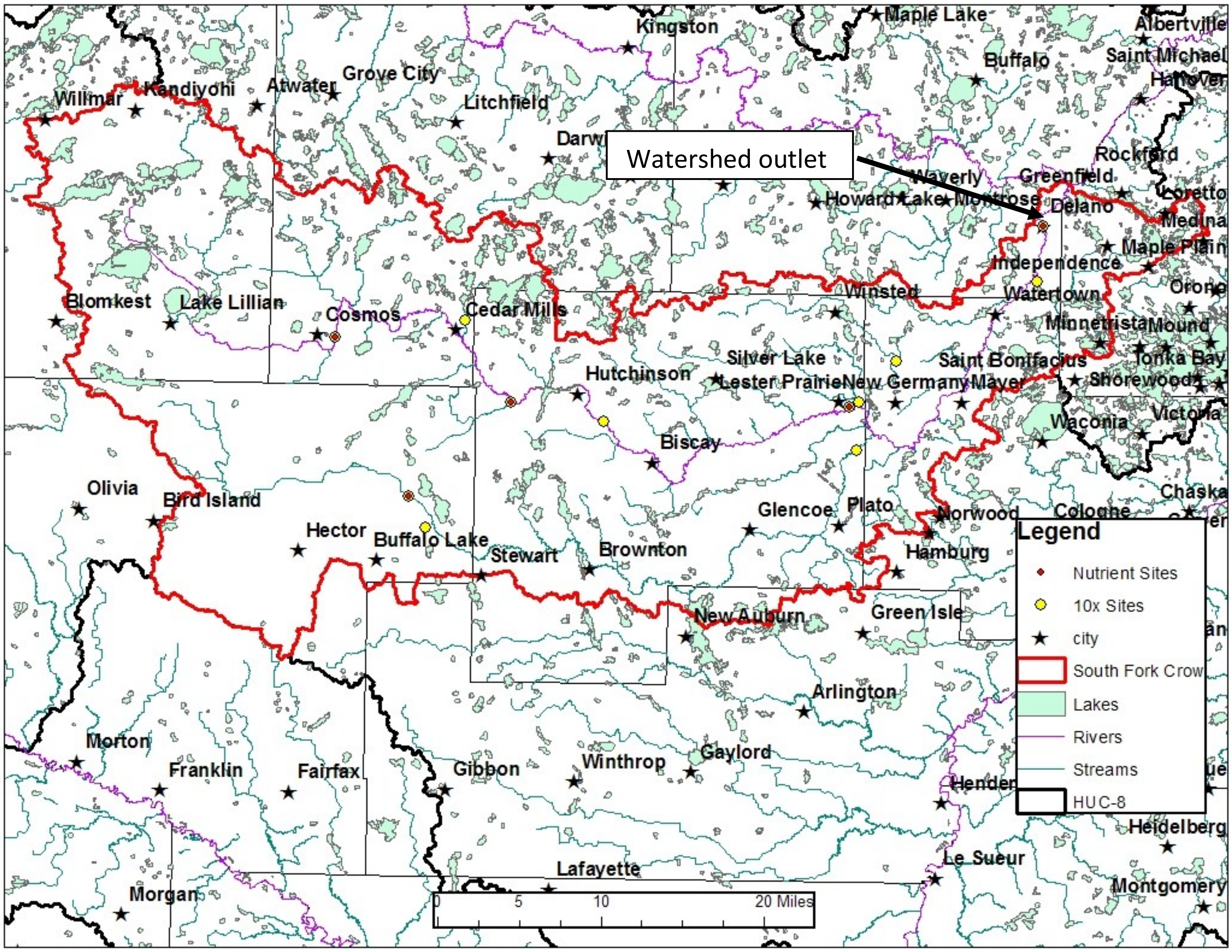
Figure 18. Generalized response of suspended algae to elevated concentration of total phosphorus from headwater streams to large rivers based on available monitoring data in Minnesota.

Stream description	Suspended algae	Periphyton*
Headwater stream (1-2 order)	Very limited	Common dependent on habitat
Large stream (HUC 10)	Limited? Need more data	Common dependent on habitat
River (HUC 8)	Common	Present dependent on habitat
Large River (6-8 order)	Abundant	Limited in main channel

*Abundance of periphyton can be influenced by several factors including: substrate, grazing pressure (biology), light availability (shade), stream morphology and nutrients.

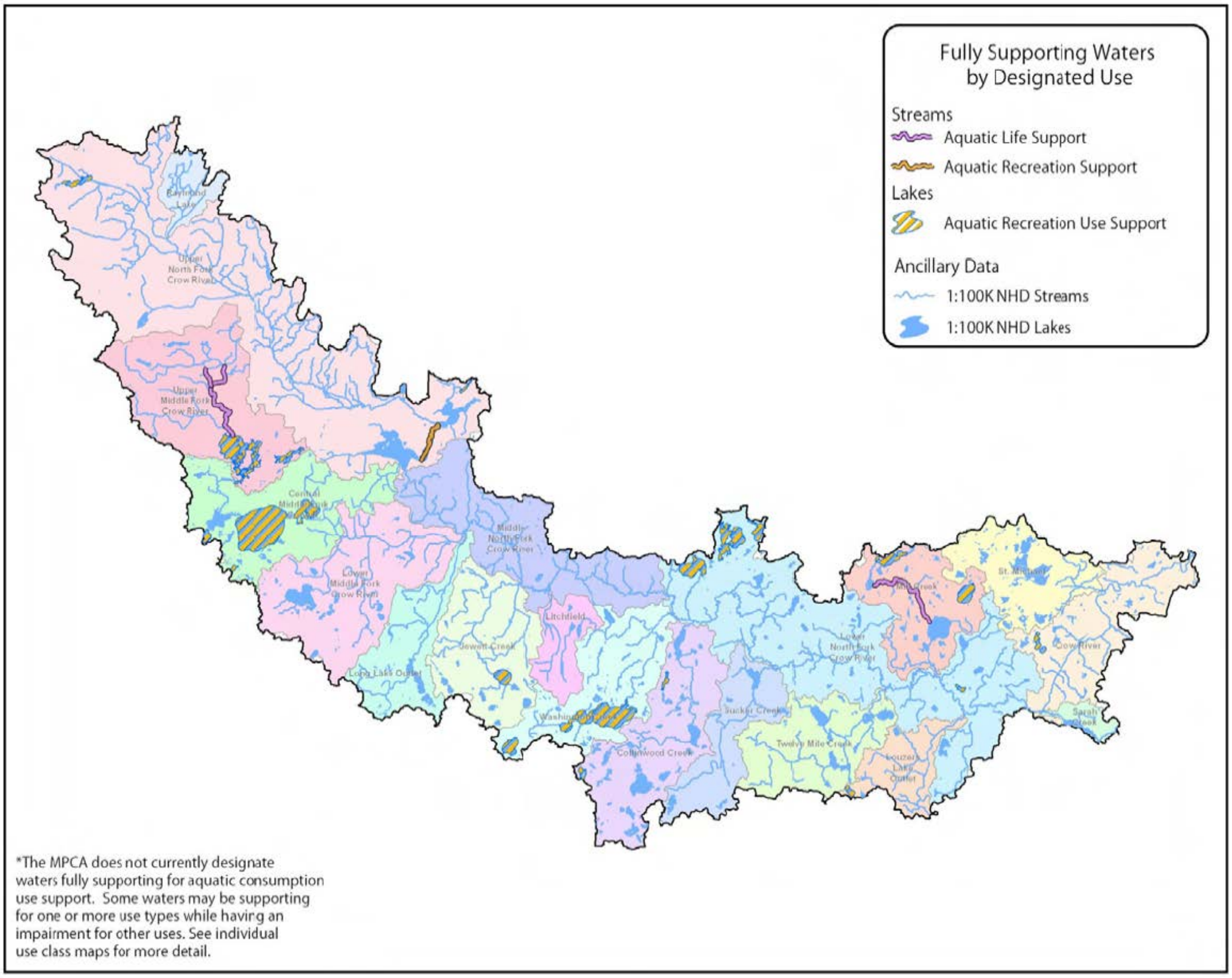
MPCA has developed a monitoring framework to measure suspended algae upstream of the more frequently monitored watershed outlet sites. To illustrate how data collection at the watershed outlet point will be used along with data from 10X sites to implement, RES, we can look to the example of the SF Crow River. The SF Crow River Watershed has 7 mainstem and tributary assessment reaches for 305(b) and 303(d) listing. There are also many smaller streams and ditches that contribute to these assessment reaches. The specific locations of existing assessment reaches were likely not located strategically to most efficiently monitor a given watershed for RES. The 10X sites discussed earlier represent upstream intermediate monitoring points on smaller river and streams. MPCA is monitoring 10X sites for 2 out of 10 years. A subset of 10X sites referred to as nutrient sites located on larger free-flowing streams and rivers will be sampled for TP and Chl-a (Figure 19). The collection of chlorophyll-a data at these sites will greatly inform the reasonable potential analysis as well as the effluent limit setting process for WWTF PS. Rivers and streams located directly below lakes are not included in this monitoring effort to prevent detecting suspended algae that is produced in the upstream lake. The lake itself will be sampled to determine if lake eutrophication standards are met. If the upstream lake does not meet lake eutrophication standards, WQBELs will be established for the lake which will reduce algae in the lake and downstream river.

Figure 19. Nutrient monitoring sites and watershed outlet site for the South Fork Crow Watershed.



Once MPCA has completed its 2-3 year monitoring program for a given watershed, designated uses impacted by TP will be characterized. This process is still developing so an example for rivers is not available at this time. Figure 20 serves as a useful example to illustrate the status of lakes in the North Fork Crow River Watershed. These maps will be important to illustrate the location of various lakes, streams and rivers in a given watershed that do not meet designated uses. WWTF PSs upstream of these waterbodies will need WQBELs if TP from their discharge contributes to the downstream impairment.

Figure 20. Fully supporting waters by designated use in the North Fork Crow River Watershed.



*Note: Lakes identified as fully support aquatic recreation use meet lake eutrophication standards

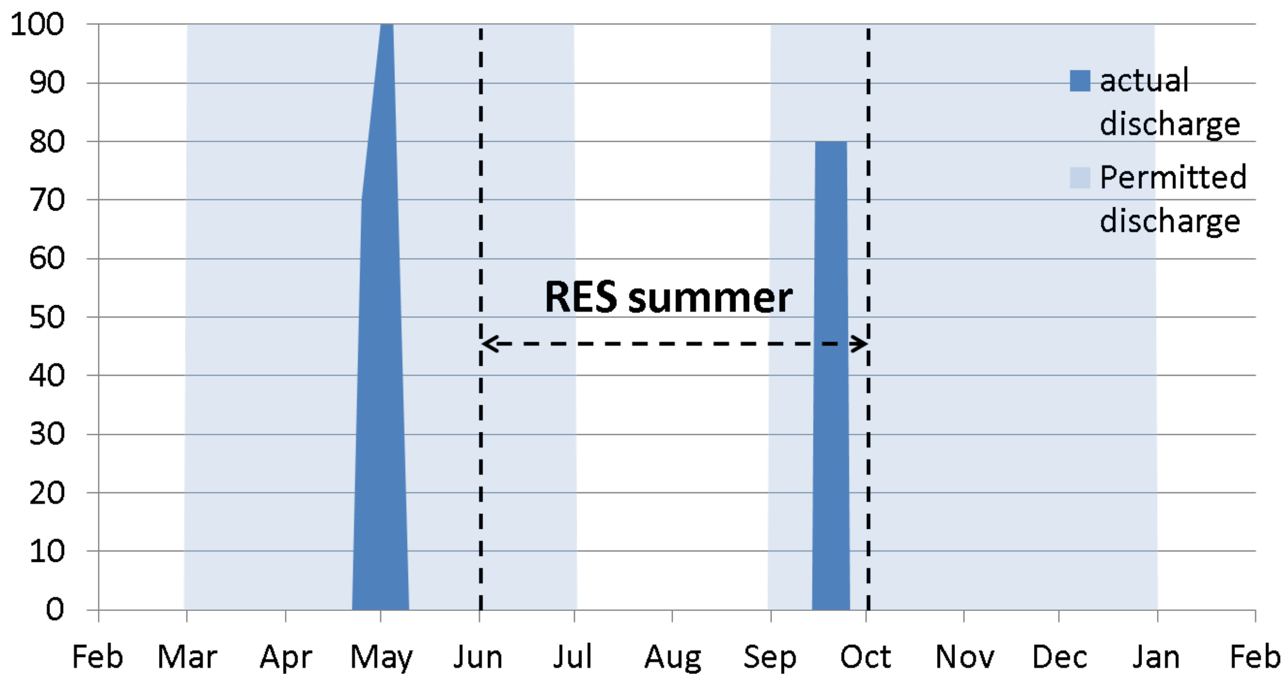
Stabilization ponds

Minnesota has hundreds of WWTF PSs throughout the state that use stabilization ponds to treat wastewater. These are effective treatment systems for small communities, and they will likely be the preferred system for these communities for years to come. The permitted discharge window for these facilities was updated in 2009 (table 9). Ponds typically discharge for one to two weeks during each spring or fall discharge window (Figure 21). Some of the permitted discharge window dates overlaps with the summer period for RES which is June through September. Predicting when or if a given pond facility will discharge in any given year is very difficult. MPCA staff has found that one or two individual weekly discharges in spring and a one week discharge in fall are normal for the majority of pond facilities in Minnesota. The volume of any given discharge is also hard to predict and often below the AAWDF of the given facility. Actual flows are based on surface area of the secondary pond and 6” drawdown per day. Many pond facilities may have the capacity to avoid the summer season most years, but a variety of factors may require a discharge during the RES summer season especially for facilities in northern Minnesota.

Table 9. Acceptable discharge periods for stabilization ponds in Minnesota.

MPCA North District		MPCA South and Metro Districts	
Spring	March 1 – June 30	Spring	March 1 – June 15
Fall	September 1 – December 31	Fall	September 15 – December 31

Figure 21. Hypothetical discharge of an individual stabilization pond located in the north district. Y-axis represents an unspecified load.



Consistent with the period for which RES are designed to be protective, the MPCA intends to assess the impact stabilization ponds over a long term period to establish effluent limits that protect designated uses. Fortunately, MPCA has already modeled the impact of TP from stabilization pond on rivers in the Minnesota River Basin. To calibrate the model, Tetra Tech assumed that the discharge from ponds have semi-circular distribution apportioned over the discharge window (Figure 22) (Tetra Tech 2009). Existing results from modeling in the Cottonwood watershed presented earlier in this document found that ponds contributed little if any TP to the Cottonwood River Watershed during summer. The MPCA is currently refining HSPF models for several watersheds. This will allow MPCA to evaluate the impact of current discharges from ponds, permitted pond discharges and reduced pond discharges. Speculation on results of this modeling would be just that at this time. MPCA is confident that discharges similar to current levels will be sufficient for some watersheds. The actual details of permit limits to protect designated uses will vary by pond and watershed. Some initial permitting categories for stabilization pond are outlined in Table 10. Permitting categories will facilitate efficient permit issuance while protecting designated uses of the receiving waters.

Figure 22. Generalized HSPF modeling scheme to represent actual long term average discharges of stabilization ponds permitted by northern regional offices. Y-axis represents portion of permitted load.

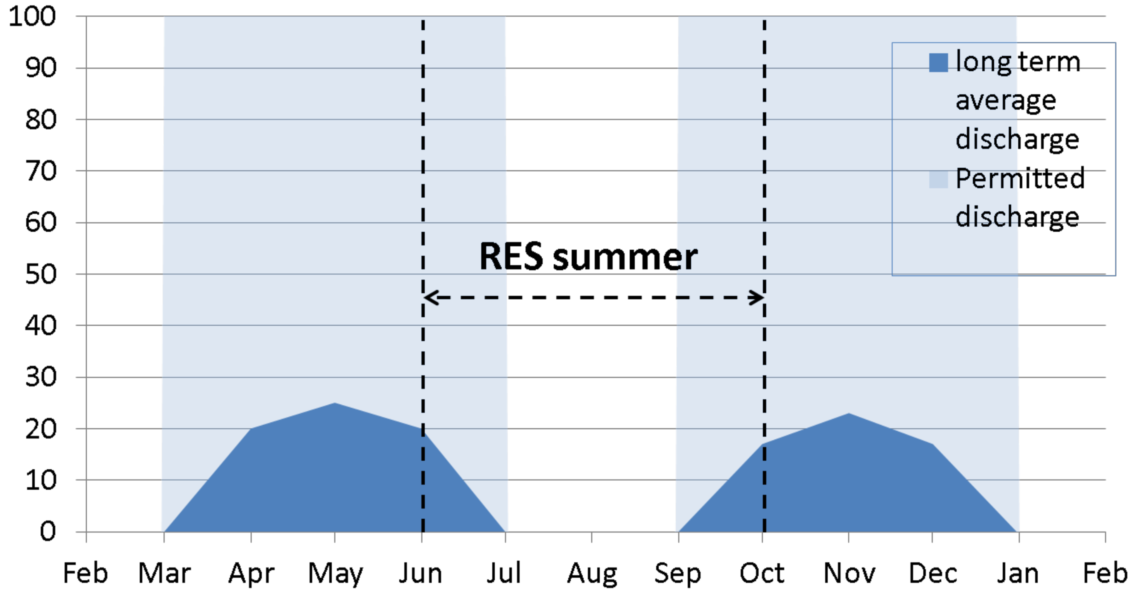


Table 10. General categories for stabilization ponds that contribute to exceedance of RES in downstream river. This table is designed to be a quick guide and it does not cover all considerations that go into a WQBEL for pond WWTF PS.

Category	**Need for extensive modeling**	**Need for additional treatment**	**Mass limit[1]**	**Comments**
Pond facilities with the capacity to avoid the summer period for RES	No	No	Possibly	Consider impact of "off-season" discharge on downstream reservoirs and large rivers
Ponds discharging to streams/rivers that meet (RES) at existing discharge	No	No	Possibly	Compare actual verses permitted limits
Ponds contribute to impairment but other sources are solution to meet designated uses	Yes	No	Yes	Reductions at larger continuous point sources are most practical solution to meet RES
Ponds contribute to impairment, improved treatment at ponds needed to meet designated uses	Yes	Yes	Yes	For cases where load from ponds is relatively large and cannot avoid summer discharge
New Facilities	Possibly	Possibly	Possibly	Designing facility to avoid summer window will reduce modeling effort

[1] Mass limits may be included in permits where analysis shows that a discharge above current actual levels might have reasonable potential cause or contribute to an exceedance of the standard

Permitting details

Averaging period

This section addresses specific considerations related to the averaging period of TP limits assigned for RES. As noted previously, RES are seasonal averages unlike other parameters where limits are established to meet critical thresholds at low flow. MPCA needs a different approach to the averaging period of TP effluent limits. Years of research into the manifestation of TP as algae in Minnesota Lakes and Rivers has led to the understanding that eutrophication, and standards to protect waters from eutrophication, are most appropriately expressed over the course of a growing season, annually, or even over multiple years. To set limits based of RES over a shorter time period (e.g., monthly or weekly limits) would be inconsistent with the intent of the cause and response nature of the standard along with years of study showing the alage response in Minnesota's waters occurs over a long period of time. MPCA will set limits to protect rivers over a long-term summer average. This approach is consistent with the current practice of establishing wasteload allocations for eutrophication impaired riverine lakes and reservoirs.

Seasonal limits:

MPCA generally favors annul TP limits, but there may be certain situations where seasonal TP effluent limits may be useful for implementing RES. By definition RES are seasonal standards so it seems logical that limits may vary by season to protect designated uses. Seasonal limits would be relatively simple for TP if was not relatively conservative which requires consideration of transport to downstream resources. Downstream resources such as lakes can act as sinks for "off-season"TP. Predicting the impact of TP discharged during fall through early spring on growth of algae in summer is difficult in river systems. Based on model results based on extensive monitoring data, approximately 88% of TP in the Mississippi River is transported through Lake Pepin during the winter (Dec-Feb). Many river monitoring programs in the state have limited site visits during winter months. The winter transport estimates for Lake are just an example. Some amount of TP is trapped in most rivers during the winter, but that amount is typically much smaller than the large load that pulses down the river from late march to early June during most years in Minnesota. These are general observations that will need site-based decisions before a permit is issued. The agency encourages biological nutrient removal (BNR) so some facilities will continue to remove TP during the "non-growing season" even though there permit may not require it.

The MPCA generally favors BNR and does not want to encourage chemical treatment unless it is the best solution for a given situation. Table 11 illustrates the projected effluent concentration based on local and downstream benefits of a chemical treatment facility and a BNR/chemical treatment facility. The more restrictive WQBEL of 0.5 mg/L is for the local reach from May to September with a less restrictive limit annual limit of 1.0 mg/L for a downstream lake. Modeling for the lake assumed annual reductions for TP. A hypothetical permit includes 0.5 mg/L limit for May-September and 1.0 mg/L limit for October – April (off-season). This example assumes that a BNR facility would need chemical addition to meet the local requirement of 0.5 mg/L TP. Some BNR facilities can actually meet 0.5 mg/L TP consistently which would require no chemical treatment to meet limits in this example (James Bauman, WiDNR). The advantage of BNR/chemical facility is less chemical use during the off-season. If there was no downstream limit for the off-season, then the

BNR/chemical facility would still reduce TP during the off-season while the chemical facility would not remove any TP beyond what is achieved by secondary treatment.

Table 11. Projected total phosphorus effluent quality for WWTF PSs with seasonal limits to comply with local and downstream limits. "Model" columns contain examples of concentration based WQBELs.

	TP effluent (mg/L) from example limit types						
Month	**Model local**	**Model downstream**	**Model combined**	**Chem. treat.: local***	**Chem. treat.: local and down.***	**BNR/Chem**: local***	**BNR/Chem**: local and down***
Jan	4.0***	1.0	1.0	4.00***	0.70	0.70	0.70
Feb	4.0	1.0	1.0	4.00	0.70	0.70	0.70
Mar	4.0	1.0	1.0	4.00	0.70	0.60	0.60
April	4.0	1.0	1.0	4.00	0.70	0.80	0.80
May	0.5	1.0	0.5	0.35	0.35	0.35	0.35
June	0.5	1.0	0.5	0.35	0.35	0.35	0.35
July	0.5	1.0	0.5	0.35	0.35	0.35	0.35
Aug	0.5	1.0	0.5	0.35	0.35	0.35	0.35
Sept	0.5	1.0	0.5	0.35	0.35	0.35	0.35
Oct	4.0	1.0	1.0	4.00	0.70	0.70	0.70
Nov	4.0	1.0	1.0	4.00	0.70	0.60	0.60
Dec	4.0	1.0	1.0	4.00	0.70	0.70	0.70
Average	**2.54**	**1.00**	**0.79**	**2.48**	**0.55**	**0.55**	**0.55**

* Anticipated effluent concentration to comply with WQBEL
** Biological nutrient removal with chemical back-up
***Anticipated concentration of facility with no TP removal

Equity and fairness of allocations for multiple discharges

When setting WQBELs multiple WWTF PSs in a given watershed will be considered concurrently. Recommended limits will reflect approaches developed to implement WQBELs based on Minnesota's eutrophication standards for lakes and reservoirs. As discussed previously consideration of all sources of TP in a given watershed will also include consideration of nonpoint sources. All WWTF PSs that demonstrate reasonable potential to cause or contribute an exceedance of a RES will receive a WQBEL. WQBELs for all facilities in a given watershed will typically be developed at the same time considering the magnitude and relative contribution of the PS to the receiving water along with the nonpoint source contribution. Implementation of WQBELs based on lake and reservoir standards has shown that some action is required from all the facilities in a given watershed, however the extent of that action is partly dependent on the relative contribution of a given facility. For example, a small facility with a relatively small contribution may be required to reduce 20 percent while a larger facility with a larger contribution may be required to reduce 75%. This is only one example; generalizations for all watersheds are difficult. MPCA will continue to strive to allocate limits to meet designated uses while striving for "fairness" within a given watershed. Limits can be refined during a RES TMDL.

Downstream impacts

Since phosphorus is relatively conservative, MPCA needs to consider downstream allocations when setting limits for a given watershed and/or basin. If all of the assimilative capacity of a given river is used by upstream dischargers, then there is virtually no capacity left for downstream WWTF PSs unless dilution is present or transport losses are significant. Fortunately we have some large models to consider multiple watersheds. For example, Mankato would need to discharge at 0.150 mg/L if all upstream watersheds were based on achieving 0.150 mg/L upstream of Mankato. This is an over simplified example, but it illustrates the complexity of assigning effluent limits in basins where multiple watersheds exceed RES. Timing of loads from various watersheds, transport losses and other factors will ultimately be considered when developing a WQBEL for Mankato WWTF.

Antidegradation / Nondegradation

Some of the rivers in Minnesota currently meet designated uses in terms of RES. Federal antidegradation regulations require states to adopt antidegradation policy and identify implementation procedures that maintain and protect existing uses, prevent unnecessary degradation of high water quality and maintain and protect the quality of waters identified for their outstanding value. Antidegradation is generally implemented through the issuance and enforcement of control documents authorizing regulated activities which impact water quality including NPDES permits for WWTF PSs. Revision of MPCA's antidegradation rule is on a separate timeline than the adoption of RES. Regardless of the status of the antidegradation rule, the intent of the rule is to protect rivers from further degradation. Downstream rivers and lakes will also be considered given the conservative transport of TP in most rivers.

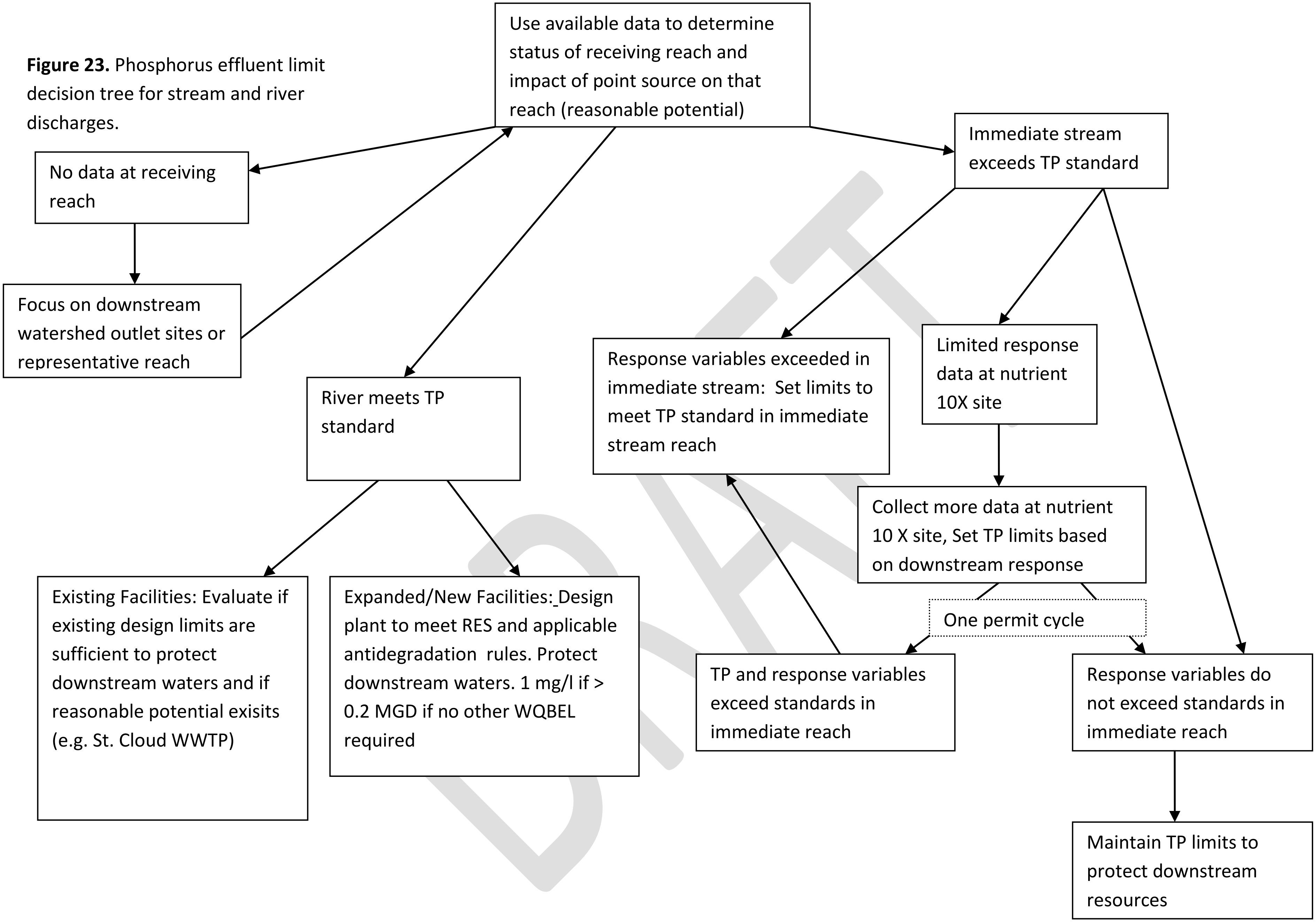
Summary

MPCA plans to take a comprehensive approach to managing eutrophication of rivers in the state and requiring point source reductions where point sources are found to have potential to cause or contribute to eutrophication. Figure 23 illustrates the process of establishing which facilities need phosphorus effluent limits. The actual calculation of a given WQBEL is a mass balance of all sources over all summer flows that results in a long-term average TP equivalent to the applicable RES of a given river (Figure 2). RES will have the most impact on point sources that discharge to watersheds with elevated phosphorus and algal concentrations during moderate to low flow conditions. This can be caused from internal loading from upstream lakes such as Heron Lake, but it is often a signature of a point source impacted river such as in the SF Crow River where additional reductions at WWTF PSs will be required beyond current limits. In watersheds where non-point sources are the dominant source of high TP levels like the Cottonwood River Watershed, MPCA will assess existing permitted limits and consider nonpoint source reductions likely to be called for in a TMDL in the effluent limit setting process. Limits for WWTF PSs in these watersheds will take into account contributions and necessary reductions from WWTF PSs and non point sources along with protecting/improving downstream resources where cumulative loads from multiple point sources represent a controllable source for achieving

RES. Finally in watersheds where RES are currently met like the Big Fork River, MPCA will focus on maintaining existing TP levels.

MPCA plans to use all available data when determining whether a discharge has reasonable potential to cause and or contribute to an excursion of RES. The outlets of MPCA's 81 major watersheds have the most robust data sets available, and MPCA will continue to do the majority of its monitoring at these sites. The data analyses and models discussed in this document can not be made without adequate flow and water-quality monitoring data. Samples will be collected at smaller streams (subset of 10X sites roughly equivalent to HUC 10 streams) within the watershed, but these sites will be short-term (2 seasons) and may not capture the variability in TP and algal levels that are driven by annual differences in weather patterns. If adequate monitoring does exist for smaller streams the agency will utilize that data to evaluate attainment of RES and set appropriate effluent limits. The MPCA will use all available data to set limits protective of the most proximate receiving water to the discharge. Given that there will be more data available at the outlet of the watersheds, limits will most often be set to protect downstream uses and immediate receiving waters when applicable. As more data becomes available upstream of the watershed outlet, reasonable potential will be evaluated using the new data when permits are reissued. Considering the substantial amount of money that will be spent on meeting RES, it is imperative that MPCA has good long-term data to represent the baseline TP concentration for calculating WQBELs. Long-term sampling will be essential to represent TP during all flow conditions which will be important for understanding source contribution and setting effluent limits for point sources. All three watersheds examined in this document illustrate the large impact flow has on the concentration of TP in rivers.

Figure 23. Phosphorus effluent limit decision tree for stream and river discharges.



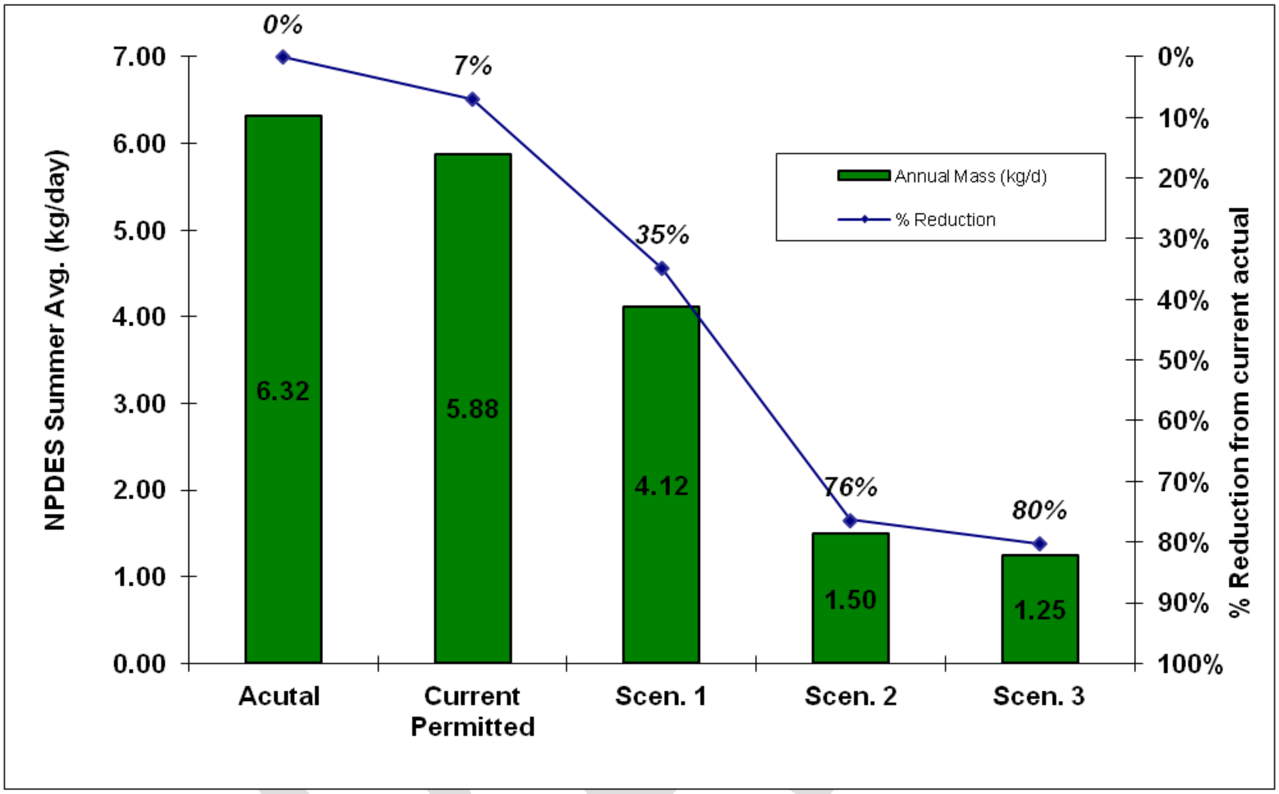
References

Tetra Tech. (2009). Minnesota River Basin Turbidity TMDL Scenario Report. Prepared for Minnesota Pollution Control Agency by Tetra Tech, Inc., Research Triangle Park, NC.

Heiskary, S., R.B. Bouchard Jr. and H. Markus (draft, 2010). Minnesota Nutrient Criteria Development for Rivers. Prepared for Minnesota Pollution Control Agency.

Appendix

Appendix 1. Historical and hypothetical WWTF PSs loads in Cottonwood River Watershed.



WLA Scenario Key

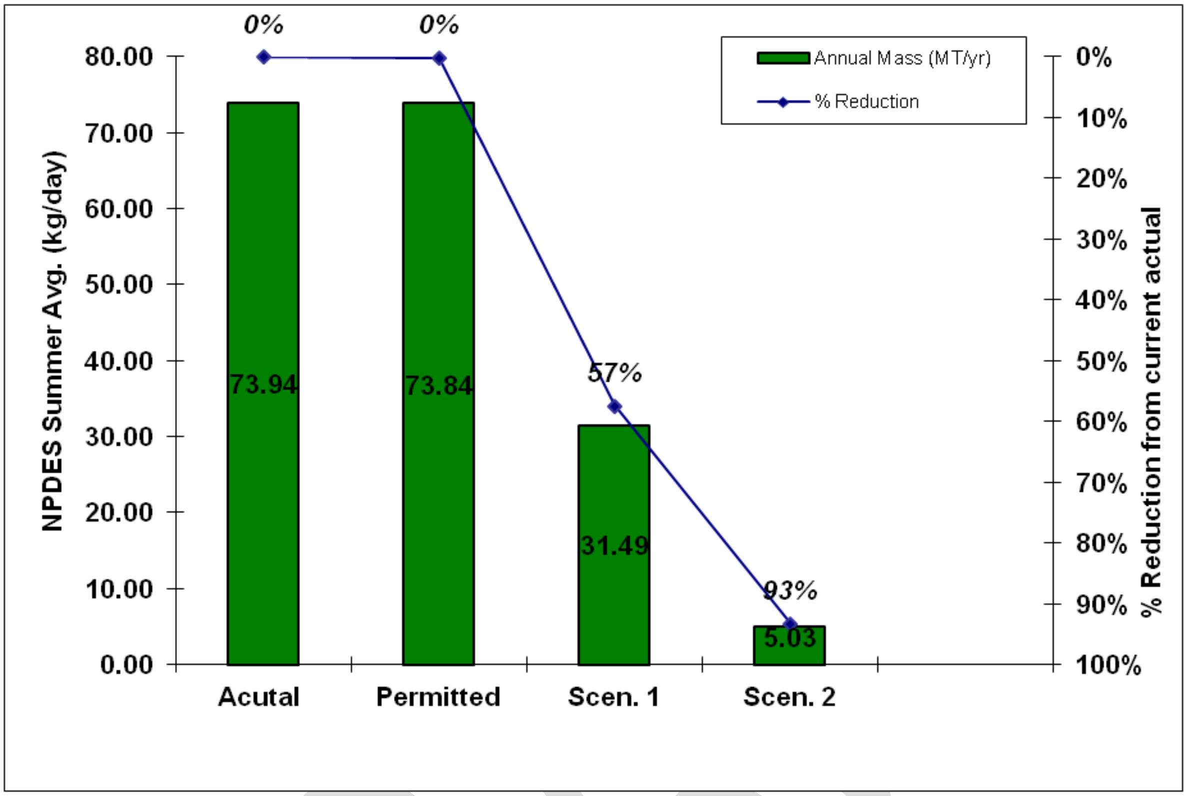
Scenario 1	Standard limit scenario.
Scenario 2	Everybody (both small and large at 1.0 mg/L.
Scenario 3	Everybody at ambient WQS.

Note: Consider that current south pond discharge window extends to june 15th (much mass could be discharged in a short order of time causing problems. What do we do about industrial categories - may need to add more.

Count	Name	AWWDF (mgd)	Scenario 1 (kg/day)	Scenario 2 (kg/day)	Scenario 3 (kg/day)
1	Acme-Ochs Plant	0.495	0.1	0.1	0.1
2	August Schell Brewing Co	0.035	0.0	0.0	0.0
3	Balaton WWTP	0.123	0.9	0.5	0.1
4	Clements WWTP	0.025	0.2	0.1	0.0

5	Dallenbach Gravel Pit		0.0	0.0	0.0
6	Del Monte Corp - Plant 114	0.890	0.3	0.3	0.5
7	Garvin WWTP	0.022	0.2	0.1	0.0
8	Highwater Ethanol LLC	0.037	0.0	0.0	0.0
9	Jeffers WWTP	0.070	0.5	0.3	0.0
10	Lamberton WWTP	0.200	0.8	0.1	0.1
11	Leavenworth Silage Co	0.000	0.0	0.0	0.0
12	Lucan WWTP	0.028	0.2	0.1	0.0
13	Marshall WTP	0.150	0.1	0.1	0.1
14	MDNR Flandrau State Park	0.420	0.2	0.2	0.2
15	Revere WWTP	0.018	0.1	0.1	0.0
16	Sanborn WWTP	0.055	0.4	0.2	0.0
17	Sleepy Eye WWTP	0.700	2.6	0.4	0.4
18	Springfield WWTP	0.780	0.9	0.1	0.1
19	Storden WWTP	0.035	0.3	0.1	0.0
20	Tracy WWTP	0.150	1.3	0.4	0.1
21	Wabasso WWTP	0.113	1.0	0.3	0.0
22	Walnut Grove WWTP	0.203	0.2	0.0	0.0
23	Wanda WWTP	0.017	0.1	0.1	0.0
24	Westbrook WWTP	0.150	1.1	0.6	0.1
Total		4.7	11.6	4.1	2.1
		7.3			
	total with ponds		11.63	4.06	2.07
	total without ponds		4.12	1.50	1.25

Appendix 2. Historical and hypothetical WWTF PSs loads in South Fork Crow River Watershed.



Scenario 1 (kg/day) summer average				
Category	**Limit (mg/L)**	**Mass (kg/day)**	**Count**	**Description**
LM	0.8	17.20	3	Large Municipal (AWWDF >1.0 mgd)
MM	1	8.61	6	Medium Municipal (AWWDF<1.0, >0.2 mgd)
SMP	2	4.34	7	Small Pond (<0.2 mgd)
SMM	3.5	1.04	1	Small Mechanical/Continuous (<.0.2 mgd)
SML	1	0.23	1	Small Municipal with existing limit due to other considerations
			-	
I1	0.1	0.07	2	Industrial 1 (non-contact cooling water/pump out)
		31.49	20	

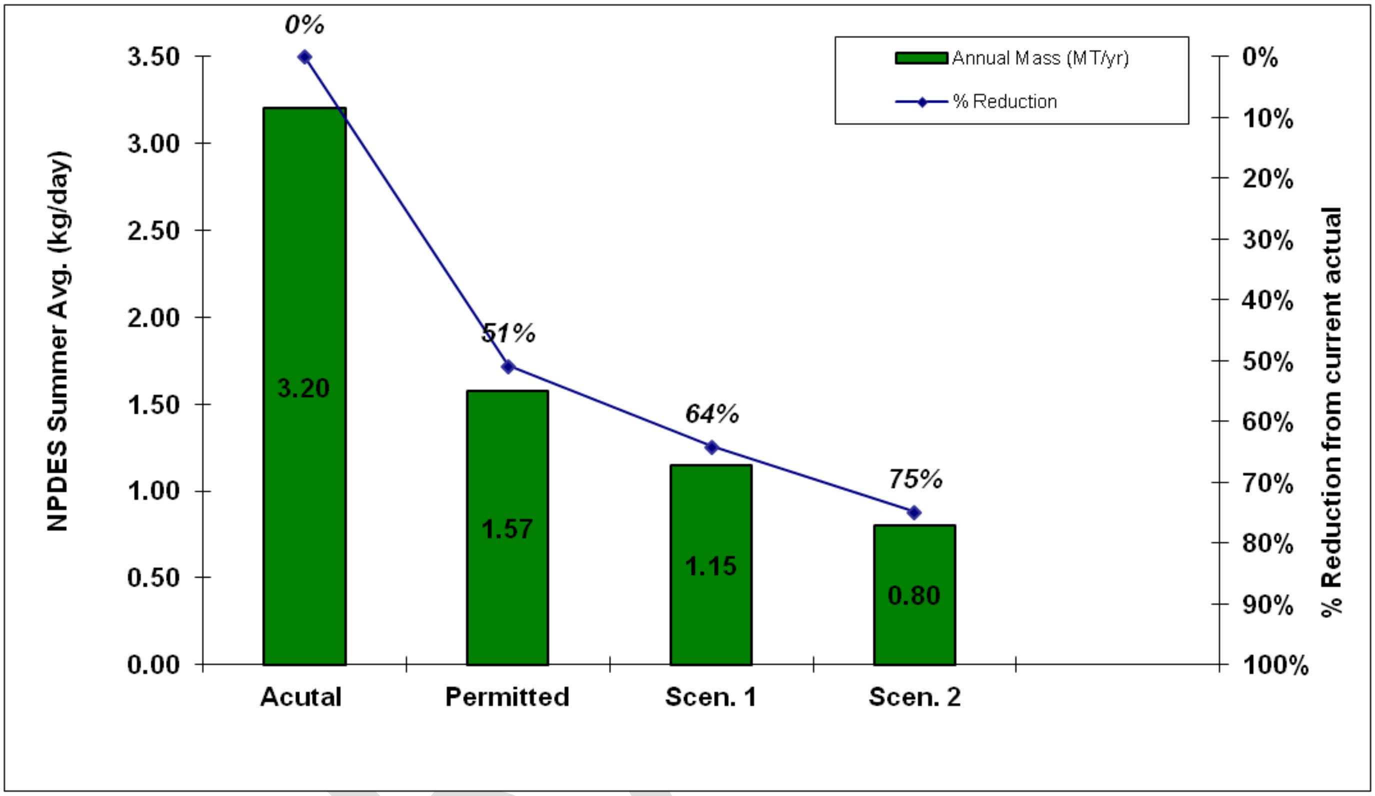
WLA Scenario Key

Scenario 1	limits given by facility classification based on lookup table.
Scenario 2	mass based on scenario 1 and a fraction of design flow to simulate variability of treatment.
Scenario 3	assumes scenario reduced through loss in delivery.

Count	Name	AWWDF/Max Flow (mgd)	Scenario 1 (kg/day)	Scenario 2 (kg/day)	Scenario 3 (kg/day)

1	Brownton WWTP	0.20	0.5	0.1
2	Buffalo Lake WWTP	0.17	1.2	0.1
3	Cedar Mills WWTP	0.01	0.1	0.0
4	Cosmos WWTP	0.09	0.7	0.1
5	Delano WTP	0.15	0.1	0.1
6	Delano WWTP	2.20	3.5	0.7
7	Glencoe WWTP	2.60	3.7	0.7
8	Hector WWTP	0.66	0.7	0.1
9	Hutchinson WWTP	5.43	9.9	1.9
10	Kandiyohi WWTP	0.11	1.0	0.0
11	Lake Lillian WWTP	0.05	0.4	0.0
12	Lester Prairie WWTP	0.36	1.0	0.1
13	Loretto WWTP	0.06	0.2	0.0
14	Mayer WWTP	0.44	1.2	0.2
15	Minnesota Energy	0.04	0.0	0.0
16	New Germany WWTP	0.05	0.4	0.0
17	Silver Lake WWTP	0.14	0.7	0.1
18	Stewart WWTP	0.11	0.9	0.1
19	Watertown WWTP	1.26	3.0	0.5
20	Winsted WWTP	0.82	2.2	0.3
Total		14	31	5
		22.1		
	total w pond		31.5	5.0
	total w/o pond		26.9	4.7

Appendix 3. Historical and hypothetical WWTF PSs loads in Big Fork River Watershed.



Scenario 1 (kg/day) summer average				
Category	**Limit (mg/L)**	**Mass (kg/day)**	**Count**	**Description**
LM	0.8	-	-	Large Municipal (AWWDF >1.0 mgd)
MM	1	-	-	Medium Municipal (AWWDF<1.0, >0.2 mgd)
SMP	2	0.75	3	Small Pond (<0.2 mgd)
SMM	3.5	0.19	1	Small Mechanical/Continuous (<.0.2 mgd)
SML	1	0.21	1	Small Municipal with existing limit due to other considerations
		-	-	
I1	0.1	0.00	1	Industrial 1 (non-contact cooling water/pump out)
Total		1.15	6	

WLA Scenario Key

Scenario 1	limits given by facility classification based on lookup table.
Scenario 2	mass based on scenario 1 and a fraction of design flow to simulate variability of treatment.
Scenario 3	assumes scenario reduced through loss in delivery.

Count	Name	AWWDF (mgd)	Scenario 1 (kg/day)	Scenario 2 (kg/day)	Scenario 3 (kg/day)

1	Big Falls WWTP	0.0432	0.33	0.23	0.00
2	Bigfork WWTP	0.0014	0.00	0.00	0.00
3	Bigfork WWTP	0.0778	0.21	0.14	0.00
4	Effie WWTP	0.0210	0.19	0.14	0.00
5	MDNR Scenic State Park	0.0155	0.12	0.08	0.00
6	Northome WWTP	0.0442	0.30	0.21	0.00
Total		0.203	1.15	0.80	0.00
		0.3			
	Total w pond		1.15	0.80	0.00
	Total w/o pond		0.40	0.28	0.00

Appendix 4. Example watersheds examined in this document to illustrate implementation of river eutrophication standards.

Watershed	Total P > RES	Response > RES	Point sources	Non-point sources	Downstream concerns
Cottonwood	Yes	Yes	Limited	Substantial	Minnesota R., Pool 2-8 including Lake Pepin
Big Fork	No	No	Limited	Limited	Rainy River, Lake of the Woods
South Fork Crow	Yes	Yes	Substantial	Substantial	Mississippi R., Pools 1-8 including Lake Pepin

Appendix 5. Basic steps to establishing effluent limits for river eutrophication standards.

The bullet points outline some of the essential considerations of setting effluent limits based on RES. The considerations are addressed in more detail in the text of.

- Determine concentration of phosphorus and response variables in river or stream downstream of discharge
- Use data from any proximate monitoring site if available. Watershed outlet sites are likely the closest station with adequate data.
- Transform flow-weighted sampling data to time-weighted for multiple years to cover wet and dry periods
- Examine downstream impacts when total phosphorus is met in receiving river (e.g. St. Cloud WWTF PSs, examine contribution to Pool 2 and Lake Pepin)
- Determine the causes and timing of excess phosphorus
- Determine the portion of load from point sources.
- SPARROW, runoff coefficients or other tools

- Determine the timing of high TP concentration
- Develop concentration duration curves (these are general categories, continue to refine this process)
- Non-point and point issue when TP is elevated during all flows
- Non-point issue when TP is only elevated during moderate to high flows
- Point source issue when TP is only elevated during moderate to low flows
- Set effluent limits to protect immediate watershed and downstream surface waters
- Compare limits needed for all downstream surface waters
- Select most restrictive limit
- Require additional monitoring if needed for immediate receiving water if downstream protection goal does not achieve RES for TP immediately downstream of WWTF PSs (e.g., Willmar WWTF PSs, limited data for Hawk Creek chlorophyll-a). Downstream monitoring for suspended algae will be required once watershed size of river reaches the approximate HUC 10 size. MPCA monitoring programs or other WWTF PSs may be or planning to monitor same site.

General scenario for most facilities where TP standard is exceeded, but response is not exceeded until downstream river

Stream description	Initial permit	Second Permit
Headwater stream (1-2 order)	Limit set for downstream river(s) and/or reservoir Monitor stream	Review data stressor id adjust limit*
Large stream (HUC 10)	Limit set for downstream river(s) and/or reservoir Monitor stream	Review data stressor id adjust limit*
River (HUC 8)	Limit set for rivers(s) and/or reservoir Monitor chl-a if needed	adjust limit*
Large River (6-8 order)	Limit set for river(s) and/or reservoir	Maintain limits

*If necessary